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The Engineer

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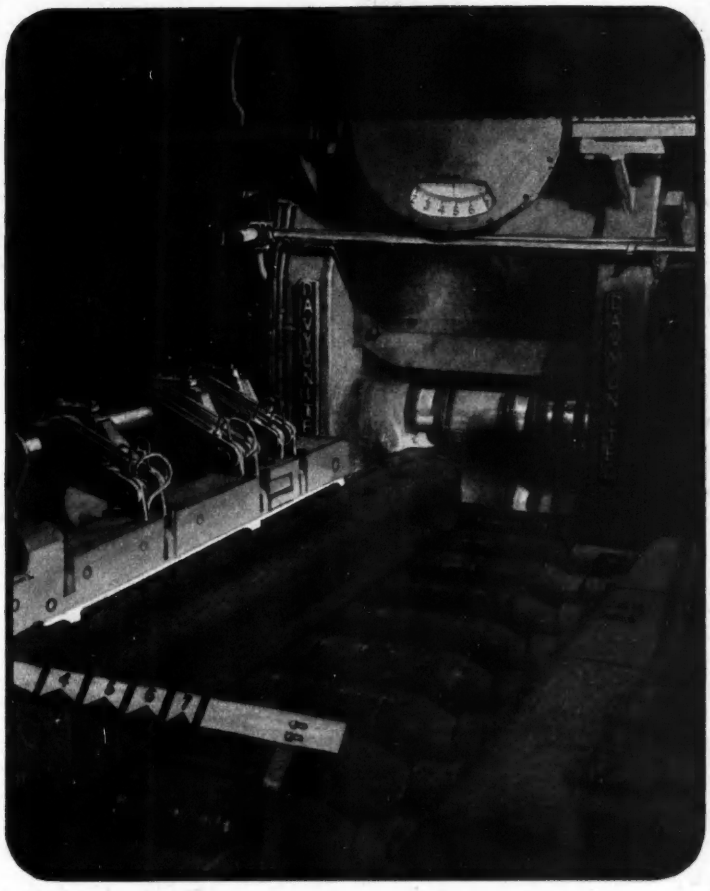


THE STEEL TUBE AGE

More than 100 S & L lapwelded steel tubes,
18½ in. outside diameter by 1¼ in. thick are installed
in the roller tables of this 37 in. blooming mill built by
Davy and United Engineering Co. Ltd.
for Round Oak Steel Works Ltd.

STEWARTS AND LLOYDS LIMITED
GLASGOW · BIRMINGHAM · LONDON

S&L

Engineering, Marine & Welding Exhibition, Olympia, Sept. 3-17, Stand No. 7 Row E, Ground Floor, Grand Hall.

GLENFIELD CONTROL

"Commercial" SLUICE VALVES

Sizes from 1½ in. to 12 in. diameter
Working Pressures up to 100 lb. per sq. in.

The Glenfield "Commercial" type of Sluice Valve provides a thoroughly reliable, light and compactly built sluice valve at reduced cost, ideally suited for low pressure service in filtration plants, heating systems, sewage works, etc.

It can be supplied with either inside or outside screw and with ends flanged, socketed or female screwed.

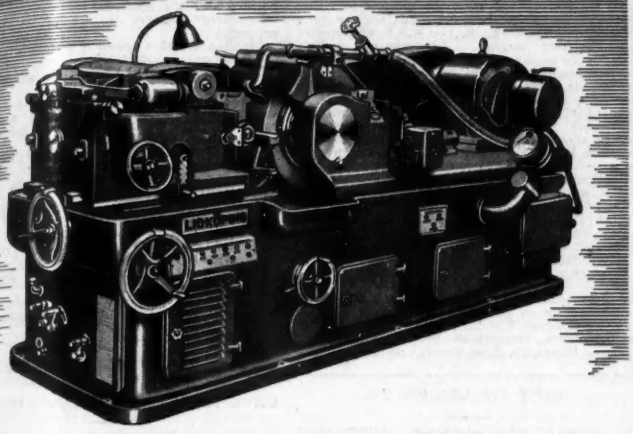
Construction is of the best close-grained cast iron with gunmetal faces in the body and on the door, and bronze spindle. The 1½ in. dia size has a solid gunmetal door on which the faces are machined direct. If required, con struction can be all iron, with faces machined direct in the body and on the door, spindle o mild steel and, for outside screws, nut o gunmetal. Construction can also be o gunmetal or zinc-free bronze for use in distilleries, nitrate works, oil refineries sea-water condensing plants, etc.

Glenfield

GLENFIELD & KENNEDY. LIMITED. KILMARNOCK

Head Office and Works : KILMARNOCK · SCOTLAND

LIDKÖPING

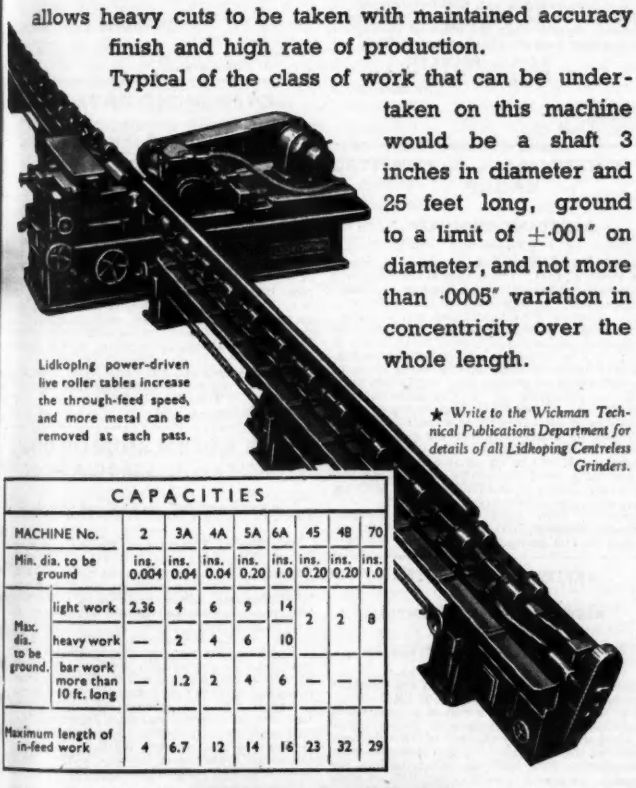


The *FASTEST* through-feed Centreless Grinders for bars, shafts and tubes

Lidkoping Centreless Grinders have been specially developed for rapid production of ground bars, shafts and tubes of almost unlimited length.

The No. 5A machine illustrated is one of the most robust machines of its type, and this rugged construction, allows heavy cuts to be taken with maintained accuracy finish and high rate of production.

Typical of the class of work that can be undertaken on this machine would be a shaft 3 inches in diameter and 25 feet long, ground to a limit of ±·001" on diameter, and not more than ·0005" variation in concentricity over the whole length.



Lidkoping power-driven live roller tables increase the through-feed speed, and more metal can be removed at each pass.

★ *Write to the Wickman Technical Publications Department for details of all Lidkoping Centreless Grinders.*

CAPACITIES									
MACHINE No.		2	3A	4A	5A	6A	45	48	70
Min. dia. to be ground		ins. 0.004	ins. 0.04	ins. 0.04	ins. 0.20	ins. 1.0	ins. 0.20	ins. 0.20	ins. 1.0
Max. dia. to be ground.	light work	2.36	4	6	9	14	2	2	8
	heavy work	—	2	4	6	10			
	bar work more than 10 ft. long	—	1.2	2	4	6	—	—	—
Maximum length of in-feed work		4	6.7	12	14	16	23	32	29

Wickman

WICKMAN *of* COVENTRY

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THE ENGINEER

ESTABLISHED 1856

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NOTICE TO READERS

All letters intended for insertion in 'The Engineer' or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

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Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

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PUBLIC APPOINTMENTS

THE ROYAL TECHNICAL COLLEGE, GLASGOW

(IN AFFILIATION WITH THE UNIVERSITY OF GLASGOW)

DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING

SENIOR LECTURESHIP IN HEAT ENGINES SECTION

Applications are invited for a SENIOR LECTURESHIP in Heat Engines Section of the Department. Candidates should have a good Honours Degree with industrial and research experience ; teaching experience an advantage, but not essential.

The engineering courses are conducted on a sandwich system which leaves the summer term free for research, opportunities for which, because of sponsored research programmes, are exceptionally good.

Salary on scale £1150 by £50 to £1450.

Further particulars and forms of application can be obtained from the Secretary, The Royal Technical College, Glasgow. E5132

SURREY EDUCATION COMMITTEE

KINGSTON TECHNICAL COLLEGE, KINGSTON HALL ROAD, KINGSTON-UPON-THAMES

SENIOR LECTURER

Applications are invited for the post of SENIOR LECTURER in the Engineering Department.

Candidates will be required to lecture in the subject of principles and design of electrical machines and/or electrical power in the full-time Degree and Diploma Courses, and should hold a good Honours Degree together with lecturing and industrial experience. Experience in research would be an added qualification.

Salary scale (men), £1040 by £25 to £1190 p.a. plus London allowance.

The person appointed will be required to commence on 1st October or as soon afterwards as possible. Further particulars and forms of application may be obtained on receipt of a stamped, addressed envelope, from the Principal, to whom the completed form should be returned not later than two weeks after the appearance of this advertisement. E5085

AMENDED

CIVIL SERVICE COMMISSION

SENIOR SCIENTIFIC OFFICERS, SCIENTIFIC OFFICERS, PATENT EXAMINER AND PATENT OFFICER CLASSES

The Civil Service Commissioners invite applications for permanent and pensionable appointments to be filled by competitive interview during 1953. Interviews will continue throughout the year, but a closing date for the receipt of applications earlier than December, 1953, may eventually be announced. The Scientific Posts are in various Government Departments and cover a wide range of scientific research and development in most of the major fields of fundamental and applied science. In biological subjects the number of vacancies is small ; individual vacancies exist at present for candidates who have specialised in palaeobotany and foraminifera. The Patent Posts are in the Patent Office (Board of Trade), Admiralty and Ministry of Supply.

Candidates must have obtained a University Degree with First or Second Class Honours in an appropriate scientific subject (including engineering) or in Mathematics, or an equivalent qualification ; or for Scientific Posts, possess high professional attainments. Candidates for Senior Scientific Officer Posts must, in addition, have had at least three years' post-graduate or other approved experience. Candidates for Scientific Officer and Patent Posts who took their Degrees in 1953 may be admitted to compete before the result of their Degree Examination is known.

Age limits : Senior Scientific Officers, between 26 and 31, but specially suitable candidates under 26 may be admitted. For Scientific Officers and Patent Classes, between 21 and 28 during 1953 (up to 31 for permanent members of the Experimental Officer class competing as Scientific Officers). Inclusive London salary scales : Senior Scientific Officers, (men) £917–£1075 ; (women) £681–£917 ; Scientific Officers, (men) £440–£812 ; (women) £440–£576 ; Patent Examiner and Patent Officer Classes, (men) £440–£760 ; (women) £440–£576. Women's rates under review. Somewhat lower rates in the Provinces.

Further particulars from the Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. S.53/53 for Senior Scientific Officers, and S. 52/53, S. 128/53 for the other posts. E5092

NATIONAL COAL BOARD

NO. 1 (WORKSOP) AREA

NORTH-EASTERN DIVISION

ENGINEERING DRAUGHTSMAN

National Coal Board, No. 1 (Worksop) Area, North-Eastern Division, invite applications for the following post :—

ENGINEERING DRAUGHTSMAN, previous experience in layout work for new plant and equipment is desirable. Possession of a Higher National Certificate in Mechanical Engineering would be advantageous. Salary within the range of £503–£610 per annum.

Applications, giving details of age, experience and qualifications, to Area Administrative Officer, Todwick Grange, Todwick, Nr. Sheffield. E5088

PUBLIC APPOINTMENTS

SHIPSTON-ON-STOUR RURAL DISTRICT COUNCIL

APPOINTMENT OF RESIDENT ENGINEERS

Applications are invited for the appointments of RESIDENT ENGINEER and ASSISTANT RESIDENT ENGINEER to supervise the construction of about 70 miles of water mains, reinforced concrete service reservoirs and ancillary works.

The work will be executed by contract, under the direction of the Council's Consulting Engineers, Messrs. J. D. and D. M. Watson, MM.I.C.E., 18, Queen Anne's Gate, Westminster. The salaries offered are £1000 and £750 per annum respectively, each inclusive of £200 per annum to be considered as a lodging and subsistence allowance, which will not be subject to P.A.Y.E. deduction at source. The appointments, subject to satisfactory service, will last approximately two years and will be terminable by two months' notice in writing on either side.

Applicants, who should have had experience of similar work, should apply in writing to the undersigned not later than 12th September, 1953, giving full particulars of age, qualifications and experience, and enclose copies of not less than two recent testimonials.

A statement should be made by the applicant that he is not related to any member of the Council or staff and has not canvassed anyone in connection with the appointment.

W. BOOTH,
Clerk of the Council.

Council Offices,
Shipston-on-Stour,
Warwickshire,
24th August, 1953. E5043

HER MAJESTY'S COLONIAL SERVICE

PUBLIC WORKS DEPARTMENT, KENYA

SENIOR HYDROLOGIST

Applications are invited for the following post :—

SENIOR HYDROLOGIST, Public Works Department, Kenya.

Duties are to take charge of the Hydrology Section of the Public Works Department, and to plan and direct the work of the staff of 18 hydrologists, hydrologic assistants, computors, &c., who deal with the collection, correlation and interpretation of data concerning the water resources of the Colony. A certain amount of field work will be involved.

Candidates, who should be between 40–50 years of age, must hold a recognised University Honours Degree in an Applied Science, preferably Civil Engineering, and must be experienced in all aspects of river gauging, rainfall run-off studies, evaporation, study of ground water and the determination of the water resources of catchment areas. Appointment is on probation for permanent and pensionable establishment, or on contract/gratuity terms. Salary according to qualifications and experience.

Full details on application.

Apply in writing to the Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, giving briefly age, qualifications and experience. Mention the reference number CDE 112/7/012. E5134

THE BRITISH IRON AND STEEL RESEARCH ASSOCIATION

A SENIOR SCIENTIFIC OFFICER OR SCIENTIFIC OFFICER

A SENIOR SCIENTIFIC OFFICER or SCIENTIFIC OFFICER is required for research primarily concerned with the responses of human operators controlling steelworks plant. The work will have special reference to the design and layout of control points in order to reduce fatigue and improve efficiency and speed of operators. Experience in ergonomic techniques would be an advantage.

Applicants for the above post must have a University Degree or equivalent qualification. Salary range for Senior Scientific Officer £740–£30–£950 per annum. Scientific Officer £500–£25–£700 per annum. Post is superannuated under the F.S.S.U.

Two ASSISTANTS are also required, one to carry out tests in the Association's laboratories and in steelworks, and one ELECTRICAL ENGINEER, preferably with knowledge of Post Office relay techniques to develop the equipment necessary for recording the results of the tests.

Applicants for these posts should have a National or Higher National Certificate. Starting salary up to £580 per annum.

Written applications only to Personnel Officer, B.I.S.R.A., 11, Park Lane, London, W.1. E5053

BRITISH ELECTRICITY AUTHORITY

HEADQUARTERS

DRAUGHTSMEN AND SENIOR DRAUGHTSMEN

British Electricity Authority, Headquarters, Bankside, London, require DRAUGHTSMEN, Grade 6, with suitable experience for work on one of the following :—

(a) Generation station layout.
(b) Foundations and civil works in connection with 132kV grid substations.
(c) Electrical layouts and diagrams for 132kV grid substations.

There are also vacancies for :—

SENIOR DRAUGHTSMEN, Grades 4 and 5, for (a) and Grade 5 for (b).

Starting salaries will be within the following N.J.B grades, according to qualifications and experience : Grade 4, £705–£819 ; Grade 5, £595–£705 ; Grade 6, £458–£595 inclusive. Pension scheme. One Saturday morning in four on duty.—Forms from D. Moffat, Director of Establishments, Winsley Street, W.1. Quote reference E/417. E5124

PUBLIC APPOINTMENTS

AIR MINISTRY

ASSISTANT CIVIL ENGINEERS

Air Ministry require ASSISTANT CIVIL ENGINEERS for duty in their Works Department for engineering work on construction and maintenance of civil engineering and buildings projects (covering barracks, workshops, runways, roads, water supply, sewage, drainage works, &c.) on R.A.F. stations and civil aviation stations. Appointments include liability for service overseas. Appointments will be in recruitment grade with starting salary according to age, viz., £628 at age 25 rising to £875 at age 34, thence by annual rises to £970 per annum. Salaries somewhat lower in provinces. Appointments are temporary but have long-term possibilities. A special allowance of up to £1300 a year, according to location, is payable in addition to salary during overseas service. Candidates must be natural-born British subjects. Applicant should hold one of the following qualifications : B.Sc. (Eng.) or equivalent, A.M.I.C.E. or A.M.I.Mun.E., or Sections A and B of the Institution of Civil Engineers or the Testamur of the Institution of Municipal Engineers. In addition, they should have at least two years' civil engineering experience on the staff of a Government Department, local authority, or a firm of consulting engineers or contractors of good standing. Location of first appointment arranged to meet candidates' wishes as far as practicable.—Application forms, quoting reference E.50/53A, may be obtained from M.L. and N.S., Technical and Scientific Register (K), Almack House, 26, King Street, London, S.W.1. E9992

CITY OF LEICESTER

PRINCIPAL ENGINEERING ASSISTANT AND ASSISTANT SUPERINTENDENT

Applications are invited for the following appointments in the office of the City Engineer and Surveyor :—

(a) PRINCIPAL ENGINEERING ASSISTANT—SEWAGE, A.P.T. IX (£790–£910).

Applicants for this position must be fully qualified, and details of duties, &c., can be obtained from the undersigned.

(b) ASSISTANT SUPERINTENDENT—SEWAGE PUMPING STATION, A.P.T. III. Housing accommodation is available for this post.

Applicants should have experience in heavy steam and electrical pumping machinery, together with qualifications, such as the Higher National Certificate or Membership of Institutions. Application forms can be obtained from the undersigned.

Both of the above appointments are subject to the provision of the Local Government Superannuation Act, 1937, and the successful applicants will be required to pass a medical examination.

Applications, including age, qualifications, details of experience, together with copies of three recent testimonials, should reach the office of the undersigned not later than the 12th September, 1953.

JOHN L. BECKETT,
M.Inst.C.E., M.Inst.Mech.E.,
City Surveyor.

Town Hall,
Leicester,
7th August, 1953. E5119

LEYTONSTONE (No. 10) HOSPITAL GROUP

ASSISTANT ENGINEER

ASSISTANT ENGINEER required at Langthorne Hospital, E.11. The successful candidate will be immediately responsible to the Engineer-in-Charge in assisting with the operation of the engineering services, including both mechanical and electrical. Candidates must have completed an apprenticeship in mechanical engineering or by other means acquired a sound practical training in mechanical engineering, and in addition have undertaken a course of study in the technology of engineering. Applicants must also be in possession of an Ordinary National Certificate of Mechanical Engineering, which includes heat and heat engines as a subject, and preferably has an endorsement in the principles of electricity, or alternatively an approved equivalent qualification. It will be an advantage if applicants also possess a good knowledge of building and repair work. Salary scale £475 by £15 to £550 per annum, plus appropriate London weighting.

Application forms from the Group Secretary, Langthorne Hospital, E.11, to be returned by not later than the 21st September, 1953. E5123

BRITISH RAILWAYS

RESEARCH DEPARTMENT

SCIENTIFIC OFFICER, GRADE 2

British Railways have a vacancy in the Research Department for a SCIENTIFIC OFFICER, Grade 2 (£478–£752), who will, for a period of two years, be seconded to work on behalf of the British Transport Commission on problems of friction and adhesion at the Mechanical Engineering Research Organisation at East Kilbride. Opportunities for subsequent permanent employment. Candidates should possess a good Honours Degree in Physics or Engineering. Certain travel facilities and eventual admission to the Superannuation Fund.—Applications to Director of Research, The Railway Executive, 222, Marylebone Road, London, N.W.1. E5130

THE MEDICAL RESEARCH COUNCIL

TRACER

The Medical Research Council have a vacancy for a TRACER experienced in tracing mechanical drawings and also capable of drawing up electrical circuit diagrams from rough sketches. Salary according to Treasury Scales.—Applications by letter to the Senior Cyclotron Engineer, M.R.C., Hammersmith Hospital, Ducane Road, London, W.12. E2371

PUBLIC APPOINTMENTS

MINISTRY OF WORKS

ENGINEERING DRAUGHTSMEN

ENGINEERING DRAUGHTSMEN required [illegible] LONDON, at RISLEY (Nr. Warrington), and BEDFORD. Hostel accommodation at Risley possibly housing at Bedford.

Experience required in one of the following categories :—

MECHANICAL : layout of factory installations including process plant, steam boilers and steam distribution, pumping, refrigeration and air conditioning.

Development of mechanical plant for a variety of research projects, including rotating machinery, heavy and light mechaniams, servo systems and pressure vessel applications.

HEATING AND/OR VENTILATING : the design of all types of heating and/or ventilating systems and general domestic engineering installations for all classes of buildings.

Salary : London, £396–£628 ; Risley and Bedford £374–£597, according to age and experience.

Applicants should have British nationality, technical standard of O.N.C. or equivalent, and have apprenticeship or suitable practical experience of at least three years, one in a drawing-office. Promotion and pension prospects.

State age, nationality, details of training, experience, to W.G.10/C.E.2 (B), Ministry of Works, Abell House, John Islip Street, S.W.1. E9970

EAST MIDLANDS GAS BOARD

LEICESTER AND NORTHANTS DIVISION

DRAUGHTSMAN

Applications are invited for the position of DRAUGHTSMAN in the Divisional Headquarters at Leicester. Grading and salary within the range A.P.T. 6/8 (£490–£665), commensurate with qualifications and experience.

Preference will be given to candidates possessing a recognised engineering qualification and having specialised experience in either installation drawings for gasworks, chemical works or similar plant ; pipework installation drawings ; reinforced concrete design, or standard steelwork design.

The successful candidate may be required to pass a medical examination, and unless already subject to a pension scheme by virtue of the Gas (Pension Rights) Regulations, 1950, will be required, if eligible, to join the Board's staff pension scheme within six months from taking up the appointment.

Applications, stating age, qualifications, present position and experience, and giving the names of two referees, should reach the undersigned not later than Monday, the 28th September, 1953.

H. B. TAYLOR,
Divisional General Manager.

Millstone Lane,
Leicester,
1st September, 1953. E5063

GOVERNMENT OF PAKISTAN

PUNJAB P.W.D., B. AND R. BRANCH

EXECUTIVE ENGINEERS

Applications are invited for two posts of EXECUTIVE ENGINEERS in the Punjab P.W.D., B. and R. Branch, on three years' contract. Pay, Rs.600 per month, plus £15 overseas pay if of non-A domicile, plus cost-of-living allowance at 7½ per cent of pay for bachelors and 10 per cent. for married men, plus Rs.50 technical pay. A Pakistani rupee = 2s. 2d. Qualifications, Degree in Civil Engineering or equivalent qualifications, with at least 8 years' experience of designing, maintaining and constructing of building and roads or municipal works. Age 26 to 35 years.

Applications on forms (and other information) available on request from the High Commissioner for Pakistan, 35, Lowndes Square, London, S.W.1, by the 15th September, 1953. E5100

THE BRITISH SHIPBUILDING RESEARCH ASSOCIATION

ABSTRACTOR (MALE OR FEMALE)

The British Shipbuilding Research Association invites applications for an ABSTRACTOR (Male or Female). The duties will consist mainly of abstracting and summarising technical and scientific papers in shipbuilding, marine engineering, naval architecture, general physics and engineering, and also dealing with technical inquiries relating to published material in these fields. A Degree in Engineering or Physics is desirable, but persons without Degrees suitably qualified otherwise will also be considered. A reading knowledge of one or more of the following languages is desirable :—Spanish, Italian, Swedish, French.

Appointment will be made within the range £3 to £600 p.a., commencing salary depending upon age and qualifications. Superannuation under F.S.S.U. —Apply to the Secretary, B.S.R.A., 5, Chesterfield Gardens, Curzon Street, London, W.1. E5081

BRITISH ELECTRICITY AUTHORITY (YORKSHIRE DIVISION)

GENERATION ENGINEER (OPERATI[illegible]

British Electricity Authority (Yorkshire Division) require a GENERATION ENGINEER (Operation). Candidates should preferably be Corporate Members of one or more of the recognised Engineering Institutions, and be familiar with the operation of modern H.P. plant. The salary will be within the provisional salary range £1325–£1800 p.a.—Applications, stating age, present position and salary, and giving details of qualifications and experience, to D. Director of Establishments, British Electricity Authority, Winsley Street, London, W.1, by 5th September, 1953 Quote reference AE/416. E

THE ENGINEER

SEPTEMBER 4, 1953

The Engineering, Marine and Welding Exhibition

THE Engineering, Marine and Welding Exhibition, which opened in London at Olympia yesterday, will continue daily, except Sundays, until Thursday, September 17th. This biennial exhibition has for many years been recognised as the most important event of its kind held in this country for the engineering and allied industries, and visitors will find that once again its scope and interest are fully equal to the high standards set by its predecessors. Indeed, the scope has been widened this year by incorporating the Chemical Plant Exhibition, and thus it now takes in a branch of industrial production which has become of steadily increasing importance in recent years. Practically every British firm of note in the engineering and allied industries is represented and the exhibits include a variety of sizes and descriptions of the latest engines, pumps, compressors, electrical plant, steam plant, constructional equipment, process plant and equipment for the oil and chemical industries, &c., as well as a host of ancillary equipment, together with materials, metals, forgings, castings, &c. The exhibition shows clearly that although there are few, if any, developments of an outstandingly new design, there has been maintained steady development in detail design which is essential to industrial progress. The stands and the exhibits are well spaced and arranged to give visitors the fullest facilities for inspecting the equipment and the many excellent models used by makers to show representative plant too large to exhibit. In a supplement which accompanies this issue of THE ENGINEER some of the plant and equipment exhibited are described. These descriptions will be continued in subsequent issues of this journal. THE ENGINEER stand is situated near the centre of the Grand Hall at Olympia and, as in previous years, is at the service of our many friends in the engineering industry.

An Attempt on the World Air Speed Record

IT has been announced by the Royal Aero Club that Squadron Leader Neville Duke, chief test pilot of Hawker Aircraft, exceeded the world speed record during trial runs over the official 3km course near Littlehampton last Monday evening. He attained 741 m.p.h. on each of two runs in one direction and averaged 703·5 m.p.h. in the other direction, the average speed being 722 m.p.h., and these figures are being submitted to the Fédération Aeronautique Internationale. At the moment an American claim to have reached 716 m.p.h. is being considered by the F.A.I. and, should this be recognised, the speed attained by Duke does not represent the increase of 1 per cent which is required when establishing a new speed record. On Tuesday a formal attempt by Neville Duke had to be abandoned, as the undercarriage on the Hawker "Hunter" failed to retract completely and after abortive manœuvre to lock the port wheel down he made an emergency landing on the starboard wheel. Slight damage was reported, and it was stated that repairs would take two to three days before a further attempt on the record could be made.

Short Courses in Industrial Technology

THIS week the Ministry of Education has issued a circular to the Local Education Authorities, Regional Advisory Councils for Technical Education, and Regional Academic Boards, which draws the attention of these bodies to the pressing need to increase the availability of advanced short courses in industrial technology. The notice states that any real increase in productivity within the next decade must result from the efforts coming from within the industry, and means should therefore be provided which will give scientists and technologists the opportunity to study new developments and techniques. According to the circular, the Ministry wishes to encourage the number of short courses of post graduate standard dealing with the latest scientific developments as applied to industrial requirements. Some 500 of such courses were provided last year, forty of which were residential and involved full-time attendance to a certain extent. They were concerned with such subjects as "Recent Developments in Electronic Techniques," "Principles of Mass and Flow Provision for Productive Engineering," and "Recent Developments in Dyestuffs." It is considered that specialised full-time courses of one academic session would be most useful, but the disadvantages of any break in employment are realised and various alternatives are suggested, while the Ministry believes that, given greater publicity, the demand for such courses would considerably increase. The Ministry calls attention to the fact that in many specialised technological fields the need for short courses is seldom apparent, due to the limited number of possible applicants, and suggests that such needs should be made known to the professional institutions concerned. In furtherance of the scheme the notice asks the various authorities to survey the need for courses for the different industries so that additional provision may be made to meet any necessary expansion in available facilities.

Technical Education

THE twelfth report, *Technical Education*, from the Select Committee on Estimates, has been published recently. According to the report the gross estimates for the Ministry of Education amount to £244,593,292 for England and Wales, and £33,971,942 for Scotland. However, the estimated expenditure in England and Wales on technical education for 1953–54 is £20,000,000, which amounts to approximately 6 per cent of the total, while the comparable figure for Scotland is 4½ per cent. It is recorded that the committee was impressed by the unanimity of opinion upon the vital part to be played by technical education in the country's present economic struggle. The report links technical education with productivity and states that this country's competitive power and, indeed economic survival, depend upon the skilful planning of further education in technical and commercial subjects. The existing buildings are admitted as being unsatisfactory for good educational instruction, and details are given of the overall progress of new building, particular reference being made to technical colleges at present under construction. Advances made in the part-time day release system of technical education are commented upon in the report, and the expansion of the number of students attending day release classes is revealed by actual figures. In conclusion, the report states that the committee was impressed by the position in England and Wales compared with that in Scotland. In England and Wales local authorities are requesting more money and permission to spend, whereas in Scotland the reverse obtains, grants of money are available, but the demand for building permission is not being pressed by local authorities. Among the recommendations made by the committee and recorded in the report, is the need to re-examine the problem of the method of building in instalments with a view to reducing the losses it involves and the proposal to allocate money to local authorities on a five-year basis.

Nuffield Foundation Annual Report

THE annual report of the Nuffield Foundation, which has been published this week, shows that the grants allocated during the year totalled £713,696, to which could be added grants amounting to £68,626 allocated against future income. Earlier in the year a brief review was given of the Foundation's work over the ten years from 1943 and the present report comments that the Foundation, possessed as it is of large resources, is fortunate in being able to undertake matters of magnitude. The report of the Nathan Committee is labelled as a timely document, and the report welcomes the recommendations made for a widening of freedom and opportunity for trusts, but is doubtful if the proposals with regard to endowed charities are justified, since, up to date, no examples of maladministration have been brought to notice upon which a call for closer supervision could be justified. The report gives details of the various United Kingdom grants and notes that twenty-six new grants, accounting for nearly half the total of £319,296, were made for biological research, while other major amounts were allocated to scientific research, mostly physical, and social research. Other grants in the United Kingdom related to functional research in building design by a special unit, and also research in rheumatism. With regard to grants in the Commonwealth, the report records that support promised for a metabolic unit at Kampala, Uganda, is the first direct grant for research in a Colonial territory, while support is continued for research in certain of the older Dominions. During the year fifty-four Nuffield fellows have been appointed under the Foundation's various schemes for training and travel.

The Use of Methane Gas

THE National Coal Board has stated that, within the last week or so, the Northern Gas Board has started to receive at Whitehaven, Cumberland, a supply of gas recovered from the undersea workings at the Haig Colliery. The gas is pumped to Whitehaven gasworks, where it is reformed by a catalytic process and delivered into the town's supply system. For some time past the National Coal Board has been collaborating with the Gas Council and the Northern and Wales Gas Boards to determine if supplies of methane gas from coal mines could be made available for use by gas consumers, and after a great deal of experimental work a system for collecting and piping the gas to the surface has been evolved. Meanwhile the two gas boards have decided how the supplies of methane, piped to nearby gasworks, could be reformed to make a useful adjunct to local gas supplies. An arrangement has been made between the National Coal Board and the Wales Gas Board whereby substantial quantities of methane gas are to be delivered from the Point of Ayr Colliery into a trunk main which is being constructed to link up a number of gasworks in North Wales. In making this announcement, the National Coal Board says that there are now sixteen collieries in various parts of the country at which methane drainage is being tried, and plans have already been made to drain at seven more. Although the quantities of methane are not likely to be great, the Coal Board and the Gas Council will continue to collaborate in attempts to put the gas to the best use in the national interest.

A Short History of Spectroscopy

By T. W. CHALMERS, D.Sc., M.I.Mech.E.

No. V—THE THEORY OF THE INTERFEROMETER

(*Continued from page* 260, *August* 28*th*)

IN its original form the interferometer was introduced to physicists in 1882 by Professor A. A. Michelson.

From a source *S*, Fig. 18, a parallel beam of monochromatic light falls on a glass plate *P* set at 45 deg. to the beam. This plate is silvered over half its back surface with the result that the beam is divided into two components of nearly equal intensity. One component is reflected at the silvered surface through 90 deg. and passes to a mirror M_1. Returning therefrom it passes through the unsilvered portion of the plate *P* and enters a telescope *T*. The second component traverses the unsilvered portion of *P* and returns from a mirror M_2 to the silvered portion, where it is reflected through 90 deg. into the telescope along with the first.

The first component, it will be noted, passes three times through the plate *P*, whereas the second passes through it only once. To compensate for this inequality a second plate *Q* of the same thickness as the first and made from the same batch of material is interposed in the path of the second component. The mirrors M_1 M_2 and the plates *P Q* are provided with fine means of angular adjustment in order that the two components may be brought nearly into

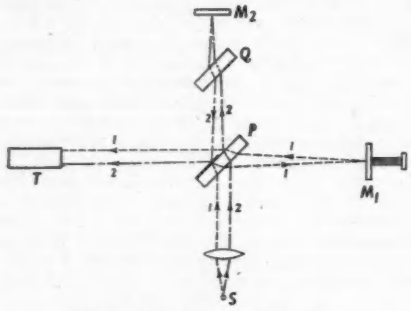

Fig. 18—Michelson's Interferometer

parallelism at the telescope. In addition, the mirror M_1 is fitted with a micrometer screw to enable its distance from the plate *P* to be varied or adjusted.

The device can be used in more ways than one. In his celebrated " ether drift " experiments* Michelson employed it to discover whether one of the components lagged behind the other as the instrument was slowly rotated through 360 deg. about a vertical axis coinciding with the centre of the plate *P*. Had there been a lag and had it been found again six months later the results of the two trials would have revealed the direction and velocity of the earth's motion through the stagnant ether. A lag was actually found, but it was too small relatively to the anticipated result to be accepted as genuine.

The instrument can also be used to measure distances in terms of light wavelengths. At one end of the scale it has been employed to reveal the expansion of a crystal under a slight change of temperature. At the other end of the scale Michelson used it to measure the length of the standard metre in terms of the wavelength of the red line in the spectrum of cadmium. His investigation indicated that in normal air the international prototype metre preserved at Paris has a length equal to 1,553,164·1 wavelengths of the red cadmium ray. Fifty years of further investigation in various countries has closely confirmed Michelson's original figure.

For our present purpose our chief interest in the interferometer resides in its use in the converse way, namely as a means of measuring wavelengths in terms of some standard unit of length—the Angstrom, the micron or other fine subdivision of the metre. For this purpose the instrument is operated by moving the mirror M_1 through some small distance—read by means of the micrometer—and by counting the number of interference fringes which pass across the field of view of the telescope while M_1 is being so moved. If the mirror is moved through a distance *l* the path of the first component will be increased or decreased by 2*l*, and if the number of fringes which pass across the field of view during this movement is *n* then the wavelength of the light being used will be given by

$$n\lambda = 2l.$$

The action of the Michelson interferometer may appear obscure, but it can be simplified if we regard the device as a means of dividing a broad beam of light from a common source into two parts, which, after being made to travel through different distances, are reunited in such a way as to interfere with one another. The two essential facts are that the original beam is of sensible width and that the two mirrors M_1, M_2 are not exactly at right angles. As a result of the slight tilting of the mirrors the two components enter the telescope superimposed and not strictly parallel and side by side, a condition which would fail to cause them to interfere.

In principle the device closely resembles the inclined mirror arrangement by which Fresnel confirmed Young's deduction from his pin hole experiment, namely, that light was a form of wave motion. Those who adhered to Newton's corpuscular theory argued that the light passing through the pin holes was diffracted, not because light was a wave motion, but because the light

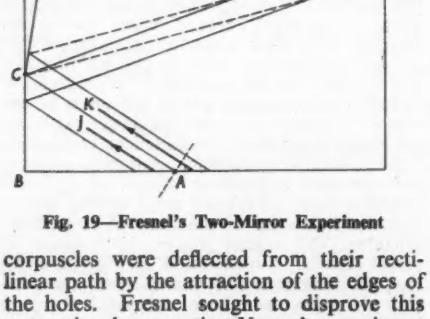

Fig. 19—Fresnel's Two-Mirror Experiment

corpuscles were deflected from their rectilinear path by the attraction of the edges of the holes. Fresnel sought to disprove this contention by repeating Young's experiment in such a way that diffraction, whatever its cause, could have no influence on the results. In one of two methods which he employed Fresnel split a parallel beam of light from a source *A*, Fig. 19, into two parts by directing it on to two mirrors *BC* and *CD*, the planes of which intersected at a very small angle ϕ. The lower portion of the beam reflected from *BC* illuminated a screen *S* over a distance *EF*. The upper portion, reflected from *CD*, would illuminate the screen over the distance *GH*. The two illuminated distances would overlap and within the area of overlapping interference would be manifested.

It will always be possible to select two elemental rays of the beam, such as *J* and *K*, one in the lower portion and one in the upper, which after reflection from the mirrors will strike the screen at the same point in the area of overlap. But although their reflections coincide the lengths of their paths, measured from a transverse section through *A*, will differ. If the difference in the path lengths is equal to an odd number of half wavelengths, the two rays will interfere destructively on the screen. If the difference is equal to an even number of half wavelengths constructive interference will be manifested. Other pairs of elemental rays such as *JK* will behave similarly with the result that on the screen there will appear a pattern of alternate dark and light lines or " fringes " indicating respectively destructive and constructive interference.

Fresnel's argument was that because the fringes were actually seen light must be a wave motion and not corpuscular. Two waves arriving in opposite phase at a point could annihilate one another and produce darkness, but it was impossible to conceive how one corpuscle could annihilate another. In this way, Fresnel's inclined mirror experiment taught the same lesson as Young's

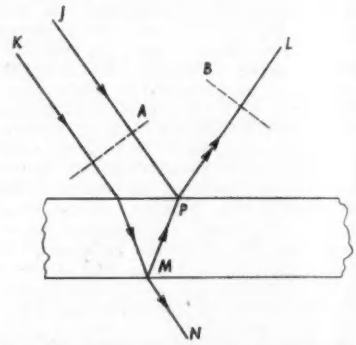

Fig. 20—Interference Produced by a Thin Film

pin hole experiment without involving the disputed factor of diffraction.

From our present point of view our interest in Fresnel's mirror experiment lies in the similarity of its principle with that of the Michelson interferometer. Both involve the splitting of a homogeneous beam into two parts and the subsequent reunion of the parts by means of mirrors in slightly tilted alignment. In both cases interference owes its origin to the difference in the lengths of path traversed by the two parts of the reunited beam.

The Michelson interferometer can also be usefully regarded from another standpoint. Several published explanations of its action are based on the equivalence which it has with the interference effects produced by thin films, in this case a film of air equal in thickness to the effective difference of separation of the two mirrors M_1 and M_2, Fig. 18, from the centre of the plate *P*.

If we accept this analogy the action of the Michelson interferometer can be explained with the aid of the diagram, Fig. 20, in which *JK* are two parallel rays of a homogeneous beam of light incident on a thin film. Each of the rays will in part be directly reflected from the upper surface of the film as shown at *JL* and in part refracted into the

* A description of these experiments and of others which followed them will be found in Chapter IV of the present author's " Historic Researches."

film as shown at *KM*. The refracted part will in turn be partially refracted out of the film as at *MN* and partially reflected back into it again as at *MP*. On emerging at *P* this portion will suffer a further refraction as at *PL*. In a broad beam it will always be possible to find two rays which are so spaced that the part of one of them, say, *J*, which is directly reflected from the upper surface of the film coincides in direction, as indicated in the diagram, with the part of the other ray which suffers refraction and is reflected from the lower surface of the film.

It is evident that when such coincidence of direction occurs the path followed by *K*, measured between any pair of transverse sections *AB*, is longer than the path followed by *J*, the difference depending upon the thickness of the film and its index of refraction. Hence, if the difference of path length is an odd or even number of half wavelengths of the light being used, the light emerging from the film in the direction *L* will show destructive or constructive interference.

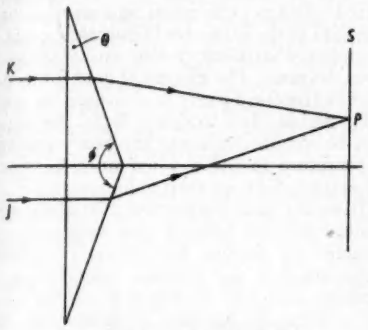

Fig. 21—Fresnel's Bi-Prism

Other pairs of rays in the original beam will behave similarly with the result that in the plane of the section *B* a series of interference fringes will be seen.

If the light in use is monochromatic the fringes will be alternately light and dark. If the light is polychromatic the fringes will show the colours of the spectrum. This action explains the colouration exhibited by a thin film of oil floating on a water surface and also the phenomenon of "Newton's rings" manifested when a plane glass surface is pressed against one which is slightly convex.

It will be noted that in the Michelson interferometer the micrometric adjustment of the mirror M_1 provides the equivalent of a means of varying the thickness of the film in a controlled manner.

Many other methods of producing interferences fringes have been evolved and have been applied in the construction of different designs of interferometer. In general it can be said that fundamentally they are either —like the Michelson instrument—developments of Fresnel's two-mirror system or of his "bi-prism" which he employed about the same time—1819—as an alternative to his mirrors for the purpose of confirming the wave nature of light.

The bi-prism does by refraction what the tilted mirrors do by reflection. It consists simply of a prism (Fig. 21), of which the refracting angle ϕ is very nearly 180 deg., or, as it may be described, of two adjoined prisms of refracting angle θ very nearly zero. If *JK* are, as in Fig. 21, two rays of a parallel beam of light incident on the base of the bi-prism one, *J*, will on emergence from the prism be refracted upwards and the other, *K*, downwards. They will, therefore, intersect at some point *P* where an interference effect will be seen in accordance with the difference in the lengths of the paths of the two rays. It should be noted that it is the optical and not the purely geometrical difference in the path lengths with which we are concerned. The interference at *P* is produced by the retardation of the one ray relatively to the retardation of the other. As drawn, ray *K* has a shorter path through the prism than ray *J* and, therefore, will over this part of its course suffer less retardation. After emergence from the prism, however, ray *K* has a longer path to traverse through the surrounding air than ray *J* and, therefore, over this portion will suffer greater retardation. The net retardations may happen to be equal, in which case the two rays will reach the point *P* in phase and *P* will therefore be a point of constructive interference. An adjacent pair of rays will then intersect at a point close to *P* and will there interfere destructively. Taking all the pairs of rays composing the original beam we can see that they will produce on the screen *S* a pattern of alternating destructive and constructive interference.

From the theoretical point of view it is obvious that the points at which the rays *J K* strike the mirrors in Fig. 19 or emerge from the prism in Fig. 21 are in effect two adjacent point sources of light analogous to the two pin holes in Young's experiment. The only difference is that whereas the light leaving the two pin holes is in the same phase the light coming from the corresponding points in Figs. 19 and 21 is out of phase. Making allowance for this difference we can apply the theory of Young's pin hole experiment to Fresnel's mirrors or bi-prism. The general result is the same, namely, the distance on the screen between adjacent fringes is a direct magnification of the wavelength of the light in use.

An example of an interferometer dependent for its action on refraction is the

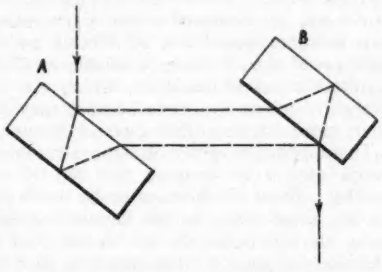

Fig. 22—The Jamin Interferometer

instrument produced in 1856 by J. Jamin. The Jamin interferometer (Fig. 22) consists of two plates of optically identical glass of the same thickness set parallel with each other and with their planes at 45 deg. to the line joining their centres. The front surfaces of the plates are clear; the rear surfaces are silvered. A beam of light incident on the plate *A* is in part reflected from the front surface and in part refracted and reflected from the rear surface. These two parts falling on the plate *B* are, respectively, partially refracted and reflected from the rear surface of that plate and partially reflected from its front surface. The two parts, if the plates are accurately parallel, will traverse equal optical paths and therefore will unite without interference after leaving plate *B*. If one of the plates is tilted about a horizontal axis out of the condition of parallelism an optical path difference will be created and interference effects will be produced.

The instrument can be used in several ways. For example, a plate of a transparent substance may be placed in the path of one of the rays passing from *A* to *B*. This will introduce a path difference and from the resultant shift of the fringes either the thickness of the inserted plate or its refractive index may be determined if the other is known.

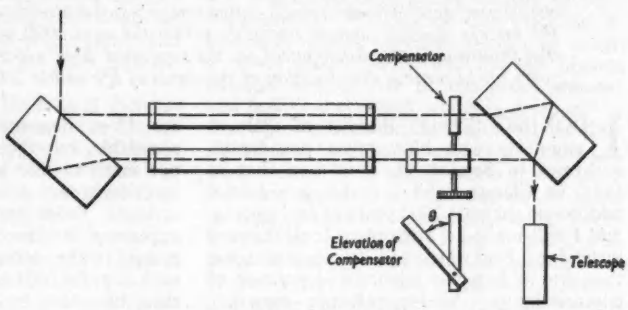

Fig. 23—Jamin Interferometer for Liquids or Gases

Alternatively, the two beams may be caused to traverse two tubes filled with liquid or gas—see Fig. 23. If one of the tubes is exhausted the absolute index of refraction of the liquid or gaseous contents of the other can be determined. If each tube is filled with a different gas a comparison of their refractive indices can be made. A modification of this method was used in 1896 by Lord Rayleigh to measure the relative refractive indices of the newly discovered gases, argon and helium.

To facilitate the use of the instrument a "compensator" may be placed in the path of the two beams. This device consists of two glass plates inclined to each other at a fixed angle θ and mounted on a common axis which can be rotated and set accurately to any angular position with the aid of an attached protractor. One of the glass plates of the compensator lies in the path of one of the beams and the other in the path of the other beam. If the tubes are filled with different gases or liquids the compensator can be adjusted to counteract the shift of the interference fringes and from the amount of its adjustment the extent of the shift can be deduced.

We have described the interferometer in terms of visible light. It is also applicable to the study of infra-red radiation. In so far as any interferometer—for example, the Michelson—involves the direct reflection of radiation from a mirror we have to note that polished metallic surfaces are very efficient reflectors in the infra-red region. In so far however, as an interferometer involves the transmission of radiation through glass plates or lenses—again as in the Michelson instrument—we have to note that glass ceases to be transparent to infra-red radiation of a comparatively short wavelength.

This fact might seem to debar most, or all, interferometers from use in the infra-red region except at its lower end. Fortunately, however, quartz, although it is opaque like glass to infra-red rays of a relatively short wavelength—actually about 4·5 microns—re-acquires transparency to wavelengths of much higher value—at about 50 to 70 microns. Hence interferometers with lenses or plates of quartz instead of glass can be used in the higher ranges of the infra-red region.

(*To be continued*)

Engineering in the Next Two Thousand Years

By LORD DUDLEY GORDON, D.S.O., LL.D.

In his presidential address to Section G of the British Association's meeting at Liverpool, delivered yesterday and reprinted here, the author points out that engineering development depends on the resources of materials and fuels available. He surveys possible sources available within the next 2000 years and comments that failure to start development on the suggested lines within the next hundred years might mean a deterioration of standards of life within 2000 years.

LOOKING through the list of eminent engineers who have given presidential addresses to Section G, it is seen that in 1951 Sir Claude Gibb gave his presidential address on the past 2000 years of engineering, and I will make an attempt to look forward instead of backward and to suggest some thoughts of how the science and practice of engineering may develop in future years.

It is perhaps appropriate to do so at the present time because up to quite recent years the energy from which the production of power has been derived has been mainly from heat created by the combustion of some material found in the earth, whether it would be wood or coal or oil. The obvious exceptions are the production of power from water falling from a high level to a lower level, which is in a sense using the force of gravity, or from wind which is the result of atmospheric changes.

The energy made available by combustion of coal has only been turned into useful work as the result of the construction of apparatus which in its turn has depended upon other minerals taken out of the earth. In the early days of the development of the industrial era no particular care was taken to preserve such resources because with the rate of demand which existed at that time they appeared to be virtually inexhaustible ; but in more recent years it has been realised that at the present rate of progress there is a limit to these supplies. This has resulted in careful investigations being made into the reserves which remain, notably the report by the Materials Policy Commission of the United States appointed by the President, to consider " resources for freedom," known as the Paley Report. This report obviously deals with the matter from the point of view of the resources available in parts of the world not covered by the Communist bloc, and does not look further forward than the next twenty-five years. Even looking forward over this comparatively short period the report comments that detailed estimates are beyond the capacity of even the most electronic intelligence and we are in fact looking into the fog of the future. This fog of the future is even more mysterious when it is realised that to-day less than 10 per cent of the population of the world is consuming half the volume of the materials now being produced from the earth's surface. A striking example is the inroads made on the Precambrian ores in the Lake Superior area, where two-thirds of the known supply has already been exhausted. This is coupled with the thought that these deposits are the result of what took place as long ago as a thousand million years and that no replacement is possible. This problem of replacement does not yet apply to timber ; it is suggested, for instance, that the Bowater pulp mills in Newfoundland can continue indefinitely at the present rate of output because timber is not being felled at a rate greater than its replacement by new growth.

Minerals which are being mined to-day are from deposits which are reasonably accessible, but the knowledge that they are not inexhaustible has naturally led to prospecting in less accessible parts of the earth's surface. From present knowledge it would appear that these further deposits add greatly to the estimated period during which such supplies will be available for the use of man, but the cost of the necessary development and the transport of minerals to the point where they are made use of will considerably increase.

Estimates as to the length of time that will be taken to exhaust the present resources of coal, which still remains the greatest source for the production of heat, vary as between different parts of the world. The Paley Report, to which I have already referred, estimates, for instance, that at the present rate of consumption the United States coal resources are good for another 2500 years, whereas estimates for the coalfields in Great Britain are limited to something like 250 years only. Some estimates are indeed as low as 150 years. This always on the assumption that the increase in the rate of consumption will not ascend even more steeply than it is doing at the present time.

The most important alternative to the use of coal for the production of heat is oil and petroleum products generally. Here, the estimates as to reserves available vary more greatly than those for coal, probably due to the fact that new sources of oil are constantly being discovered and developed, whereas this does not apply to coal to any great extent. The Paley Report suggests that the present known sources in the free world may be exhausted within a generation. This estimate would not be affected by the addition of the resources available in Communist controlled countries, which are unlikely to become exporters because they can do no more than meet their own requirements.

These estimates probably ignore resources which may exist beneath the bed of the oceans. These would have to be developed on the same lines as the deposits already being worked under the sea in the Gulf of Mexico, but even if these deposits do exist, new methods of exploitation would have to be devised at a greatly increased cost. The possibilities of this source of oil are discussed in Miss Rachael Carson's most fascinating book, *The Sea Around Us*.

The other obvious source of fuel is natural gas developed on the lines already in use in Canada and in Italy. It does not appear from information at present available that this source will make any considerable contribution to world sources of heat over the long period under consideration.

Sources such as peat and oil shale over this period are probably not worth considering.

So much thought is given to-day not only by scientists and engineers but also by the general public to the possibility of development of nuclear energy, that less anxiety exists about the question of fuel supplies than would otherwise be the case, but at the present stage of development materials such as uranium have to be found and are at present being sought all over the world. This is an interesting example of how material for which there is no important known use in one generation may be in great demand in another. Fifty years ago uranium, by virtue of its close similarity to tungsten, was noted as a possible alloy to be used in tool steel, but not much progress was made. To-day we find the somewhat dramatic development of the creation of Uranium City and Port Radium in Canada, the former, I believe, being largely constituted from materials moved from the former town of Goldfields.

In South Africa the gold mining industry is paying a great deal of attention to the recovery of uranium, which until recent years would have been looked upon as not worth extracting from tailings dumps even if its presence had been realised. The strength of the South African position is that it is worth while working the mines for the gold alone. Gold is in a quite exceptional position compared with any other metal because it is a basic medium in the exchange of currencies, and no completely satisfactory alternative has so far been devised. The mining of gold for its own sake is therefore likely to continue for a very long period, and uranium from this source can be obtained without the heavy overhead expenditure involved when uranium has to be extracted for its own value only.

It would be quite inappropriate in a presidential address making this wide survey to attempt to discuss the details of possible developments in nuclear energy. It is perhaps sufficient to say that, so far as we have gone at present, progress has been made in the direction of producing heat which is made use of to create power as an alternative to combustion of fuels and is used in the form of normal heat engines. Maybe there will come some development by which nuclear energy could be used, so to speak, direct by the use of apparatus not yet thought of.

At present the development of nuclear energy appears to be based on the availability of uranium and possibly thorium, which, like other metals which have to be mined, come from resources which at the present rate of consumption may well be exhausted before the period of 2000 years. There is, however, the thought that by a process of reaction there may be a type of reproduction, the so-called breeder piles,* which would greatly reduce the amount of uranium required and so extend the life of the discoverable resources. It may not be outside the bounds of possibility that in the course of development some alternative method of producing nuclear energy might be evolved which would displace the use of uranium.

An example of the expectations which are raised by the present progress towards the development of nuclear energy is well indicated by the suggestion, made some months ago, that the coal industry would be prudent to assume that before long the production of power from nuclear energy will be no more costly than coal and for this reason research should immediately be undertaken with a view to finding an output for surplus coal. On the other hand, it has been suggested by Sir Charles Darwin in his book, *The Next Million Years*, that the amount of uranium at present in the earth is such that if it is to remain the only source from which nuclear energy can be produced, it is unlikely to be as much as can and will come from coal. It is unlikely to be ten times as much and certainly will not be one thousand times

* Since this paper was written, the existence of a breeder pile in the U.S.A. has been announced.

as much, so that if this assumption is correct the supply would be exhausted well within the period of 2000 years which is under discussion.

The use of the so-called hydrogen bomb as a destructive agent has already received some attention, but just as fire which was first used by man for cooking and warming and then as a destructive agent was later harnessed for the production of power, so it is possible that the almost unlimited amount of hydrogen recoverable either from the air or the sea might be used as a source of power. Sir Charles Darwin's book, which I have mentioned, indeed expresses the hope that it will never be possible to release all the ordinary hydrogen in the earth because it might well involve the destruction of our planet. But there may be hopes of successful use of heavy hydrogen as a fuel.

Sources of power which do not depend on the creation of heat by combustion are obviously water power and wind. The attraction of these sources of power is that it is difficult to conceive that they could be exhausted within the next 2000 years, though there would presumably come a time much sooner than that when all the possible sources of hydraulic energy had been developed. This will surely some day include the use of energy derived from ocean tides. Here is an immense source of power which is inexhaustible. Professor Haldane, however, has sounded a warning that the final result of unlimited development of tidal power would be to increase the braking action of tides very considerably so that the rotation of the earth would slow down and the day would become longer. The moon would again begin to approach the earth and the final result would be the destruction of this planet; but, as he calculates that this final judgment is not likely to take place before A.D. 36,000,000 we need not be greatly concerned about it as a deterrent during the next 2000 years.

Experiments for the production of power from wind are already being undertaken, but in this case it would appear that the constant variations in the amount and velocity of movement of air in any given spot are so great that we cannot yet see how a large and constantly available source of power could be developed.

No attempt has yet been made to use the heat available in the inner part of this planet. There are from time to time spectacular demonstrations in the form of volcanic eruptions which give an indication of the immense resources available. These would have to be tapped by some form of excessively deep boreholes and controlled by some means not yet thought of. The danger to be avoided is obviously the release of forces which would cause some terrible catastrophe similar to the destruction of Krakatoa in 1883.

There remains solar energy as a possible source of power, but again limited as to location and magnitude, a subject on which Dr. Parker, of the National Coal Board, gave a most interesting paper more than two years ago.

Generation of electricity from water power, wind, tides or solar energy can be undertaken only in those places where Nature has made such sources of energy readily and constantly available. They will therefore in the future, if they are to be made of general use, depend on the transmission of power over great distances. Progress has already been made in this direction by the transmission of electricity in the form of direct current at high voltages, but such means of transmission must always be very costly, not only from the point of view of the original installation, but also as a result of the high charges for maintenance. This difficulty would be overcome if some form of "wireless" power transmission could be devised. These intermittent sources of power will become more valuable when some means are found at long last for the large-scale storage of electricity.

It seems certain that in future years the progress of engineering science will be more rapid than it was in the nineteenth century for the reason that so much knowledge has been accumulated and that certain principles are so well established that they can no longer be doubted.

I refer, for example, to the laws of thermodynamics including acceptance of the Carnot principle, as well as to the gas laws of Boyle and Charles. The properties of steam at temperatures and pressures well beyond those in present use are well established, while in another direction we are now at home in the field of sub-zero temperatures. By parallel improvements in instrumentation and the efficiencies of engines, machines and structures can be more closely studied, with advantage to the economy of constructional materials and of fuel.

There may be other sources of power which are as yet unexplored. I will venture to suggest that the force of gravity may some day be used as a source of power. It is used to-day indirectly in water power generation of energy, but if we can learn how to control the force of gravity itself great developments would follow. If it could be controlled or even generated and its intensity and direction varied at will, it could be used for many purposes, particularly for travel. This suggestion is obviously quite visionary. Knowledge to-day regarding gravitation is slight. It is true that the latest mathematical efforts have led Einstein and others to believe in a connection rather than a mere similarity between gravitation and magnetic force. No physical meaning to these equations has yet been found and it is possible that as knowledge increases it may be found that there is no hope of the control of this force by the inventions of man.

One of the most important results to mankind in the development of the science of engineering is the increase in the ease of movement from one part of the world to another. It was not very long after the introduction of the steam engine that it was applied to travel by means of railways and steamships. The same can be said of internal combustion engines and to a lesser degree the steam turbine, which has so far been applied for travel purposes almost exclusively to ship propulsion, though there have been examples certainly in the British railway system of steam turbine locomotives.

The increased speed and range of travel which the development of science can provide has always been a favourite subject of the novelist who makes the future his theme. Jules Verne not only imagined beforehand with considerable accuracy the development of the submarine, but also in his novel *The Clipper of the Clouds* describes something similar to the present-day helicopter. H. G. Wells, in his novel *War in the Air*, was not quite so accurate in his forecast, since he visualised the dirigible airship as possessing greater striking power in war than the aeroplane.

Most of these forecasts assume the use of forces which were well known at the time of writing. Jules Verne, for instance, in his novel *Voyage to the Moon*, imagined a projectile propelled by the explosion of gunpowder in a cannon composed of a vertical bore in a mountain. In the same way to-day proposals for inter-planetary travel assume the use of rocket propulsion on the basis of developments now taking place, but the control of the force of gravity, if it could be achieved, would not only make the return journey more feasible, but would overcome the disadvantages of the varying forces of gravity during the journey and on arrival at planets which, being smaller, have a lower force of gravity than our own.

Another alternative source of power is the use of some chemical action not yet perfectly understood. Working on the principle of thermodynamics, engineers attempt to design a prime mover which will use the highest possible temperature of the agent selected and collect the energy which is given off as that agent is reduced to the lowest possible temperature; but in the case of the human or other animal body which exerts power there is no corresponding absorption of an agent at high temperature rejected at a lower temperature. In the human body, for instance, energy appears to be accumulated in the form of food, particularly carbohydrates, without any appreciable rise in temperature and when doing work such as turning the handle of a winch or hauling on a rope, no appreciable drop in temperature takes place. When thinking of a period as long as 2000 years is it unreasonable to suggest that a source of power based on a more or less isothermal chemical reaction may not be evolved ?

So far as the immediate future is concerned, it appears to be certain that, with regard to mechanical engineering, power units will become almost exclusively those giving power by rotating rather than reciprocating motion. The first known prime mover making use of steam is generally accepted to be the classical reaction turbine of Hero, but when the steam engine began to be developed as a practical working unit in the latter part of the eighteenth century, the reciprocating motion was the one generally employed. Both steam and internal combustion engines were developed on these lines though the greater part of the power they developed was applied through flywheels and pulleys to a rotating motion, the obvious exception being the use of reciprocating pumps and compressors driven either by coupling through the crankshaft or directly by tail rod drives.

Steam power was first used on a considerable scale for pumping water which had for a long time been achieved by the plunger type of pump, the power being provided by men or by horses. This may have influenced the lines on which the steam engine was developed, but in any case designers and constructors were limited by the materials then available.

The generation of electricity and the use of electrical power has always been developed through rotating generators and electric motors. It was therefore a natural step forward that the prime mover should also be rotating in the form of either steam or gas turbines. The application of power by rotational movement has long been known in the case of centrifugal pumps and other similar apparatus and in recent years there has been considerable development of turbine compressors for various uses, mainly for the larger sizes. The replacement of the immense blowing engines associated with the early days of blast-furnaces, which are to-day superseded by rotary blowers, is an example which immediately comes to mind. There is every indication that before very long this will apply to smaller sizes as well. Gas turbines and jet propulsion for aircraft are already accepted almost as normal and a beginning has been made with similar propulsion for motor-cars and ships. It seems, therefore, quite reasonable to suppose that

certainly within the next fifty years reciprocating motion will become the exception rather than the rule.

Turbines and compressors tend to adopt constantly increasing speeds and higher temperatures, so that weight and space occupied are constantly being reduced.

Great attention is being paid to-day to increasing the speed and range of air travel and it is confidently expected that long-distance travel at supersonic speeds will become common practice within the next twenty years or so. No less an authority than Sir Frederick Handley Page has suggested that the next increase in speed when it does come will be in the form of a considerable jump to something like 900 miles an hour, and even higher speeds are evidently being considered. Certainly there have been references in the Press to the building of so-called flying saucers at these very high speeds. If such advances are to take place it would seem essential that they should be accompanied by some means of reducing greatly the take-off and landing speed of aircraft, not only from the point of view of safety, but also with a view to reducing the size of airfields and the monstrously long runways which high speeds demand. This would also have the advantage of making it possible to construct airports closer to the great centres of population.

The problem of the reduction in the noise created by aircraft will surely one day be solved, as it has been so successfully in the case of motor-cars. Indeed, when supersonic speed in level flight becomes the general rule, some means for the elimination of noise will become a vital necessity.

Now all these advances in the science and practice of engineering are the result first of all of the accumulation of knowledge as the outcome of the achievements of the past, but the result of improvements in design and practice can only be made use of as a result of the materials which become available. These new or improved materials again are the result of the accumulation of knowledge being constantly added to by research, and it all goes back to the availability of the mineral resources which came into being millions of years before man was ready to make use of them and are now being so rapidly exhausted—rapidly, that is, in comparison with the age of the world or even the period of the existence of man.

Whatever new sources of power may be developed, they can be made use of only by power-producing units which are made of materials which have to be extracted from the earth's surface, or produced in some other way. The power is transmitted to machines in factories which are constructed of much the same materials. The machines in the factories produce goods which again are made of the same materials, all taken from the earth's surface. In this connection to-day we think mainly of iron and steel products, though the use of other metals and plastics is becoming more and more familiar.

This leads quite naturally to the consideration of how long existing sources of supply for fuel and minerals are likely to last as demands increase, and what is to take their place when these supplies are eventually exhausted.

The use of iron and steel products, not merely for engineering apparatus, buildings and similar capital goods, but also for consumer goods, is so universal that it seems quite reasonable to measure the standard of living by the consumption of iron and steel and its final products per head of population.

The accompanying table compares estimates of steel consumption per head in various countries (based upon ingot production less direct exports, ignoring "indirect exports" of steel in metal goods). It illustrates the point made in the report of the productivity team representing the iron and steel industry which visited the United States in 1951 :—

"It may be said without exaggeration that the American way of life manifests itself in a material sense primarily in the form of goods containing steel"

Apparent Consumption of Steel per Head
(in ingot lb)

	Average 1937–38	1948	1950	1951	1952
U.S.A.	641	1131	1237	1343	1138
Canada	346	623	614	793	737
Sweden	482	625	645	715	—
Australia (*a*)	428	415	538	643	—
U.K. (*b*)	495	614	630	642	706
Germany (*c*)	596	273	469	497	654
Belgium-Luxembourg	353	757	501	488	527
Netherlands	333	326	370	428	—
France (*d*)	289	408	332	407	518
Italy	123	110	141	166	—

(*a*) Year ended June 30th.
(*b*) Adjusted for stock changes.
(*c*) Includes Saar, 1937–38 ; West Germany only, 1948–52.
(*d*) Includes Saar, 1948–52.
Source : British Iron and Steel Federation.

This table is a clear indication that with improved standards of living for which every country in the world is striving, there must be increased consumption of steel per head for as long as the available sources of raw materials make it possible to meet the demand. The table also indicates that the increase is directly related to improved standards ; that is to say, those countries in which productivity is known to be low lag far behind those countries with high productivity.

There seems no reason to suppose that this tendency to increased consumption of steel will diminish during the next few hundred years. It is reasonable to expect that the standard of living will be gradually raised throughout the world and that even if the present rate of increase in population does not continue as rapidly as it is now doing, nevertheless the total demand will continue to increase.

There are therefore two problems which have to be solved : first, the provision of sufficient power to meet world demands ; and secondly, the supply of materials which will make the application of that power useful to mankind, and it is the science of engineering which will be mainly responsible for solving these problems after the possible solutions have been indicated as the result of research. There is every indication that iron and steel products will continue to be the main source of supply certainly for the next few hundred years, and there is still great scope for development in the production of iron and steel in the direction of improved composition and structure of metals so that the same results can be achieved with a much smaller weight of material. It has been suggested, for instance, that structural steel, if more completely homogeneous, could be so greatly increased in strength that the framework of a steel building might present the appearance of a spider-web construction compared with what we are accustomed to see to-day.

Now, of even greater importance to the future of mankind than the necessary supply of materials to provide all the equipment which, though starting as a luxury becomes a necessity as the standard of living increases, is the provision of sufficient food which again is in greater demand as the standard of living increases.

Sir Charles Darwin, in his book to which I have already referred, has some interesting thoughts on this subject. Certainly there has been noted the tendency for the rate of increase of population to decrease with an increased standard of living, but even so it seems not unreasonable to assume that the population of the world may double itself in a century. This leads to the interesting conclusion that in 2000 years the population would have increased a million fold and would require a million times the amount of food at present being produced in the world. It is difficult to imagine that this could be achieved, and long before the period of 2000 years is exhausted there would be constant struggle to provide by some means or another sufficient food to feed the population.

Now this problem is already beginning to manifest itself and at all events in this country we have become so much accustomed to rationing that it is held as a great achievement when the controls which go with rationing are removed.

Agricultural science is constantly showing how both vegetable and meat supplies of food can be increased, but these methods in almost every case bring engineering into play to provide the solution. One possible means of increasing agricultural resources is the irrigation of deserts which up till now has been achieved by diverting water from river systems, so widely used for many centuries in Egypt and now being developed in India. It is possible that future developments might take the form of converting sea water into fresh water by means of condensation or some other mechanical contrivance on a scale far larger than any method now in use and, by a great development of civil engineering combined with afforestation, irrigate vast areas such as the Sahara and make them available for agriculture.

Broadly speaking, it may be said that up till now agriculture has been possible in those regions of the earth where water, evaporated from the ocean and passed in the form of clouds to the land, is precipitated in the form of rain and one of the functions of engineering in the future may be to reproduce that action by mechanical means so that the effect of what would be the equivalent of controlled rainfall could be applied to any section of the earth's surface.

Mention of the sea as a source from which the demands of man can be met makes one turn to some of the suggestions made by Miss Rachael Carson in her book *The Sea Around Us*. Hitherto the sources for the creation of power and its use in the production of materials and finished goods for the use of man, have been sought almost entirely from the dry land, but it is suggested that the ocean is the earth's greatest storehouse of minerals. Apart from the estimated resources of reserves of fuels in the earth, estimates have been made of the reserves of the more important metals, in addition to iron ore. Manganese ore does not appear at the present time to have any great economic reserves, but the Paley Report suggests that improved mining methods can be expected to meet the demand for many years to come. Aluminium, as at present produced, depends on supplies of bauxite ore, provided there is an ample supply of electricity at a low price, which has led to the development of hydro-electric power for this purpose. No doubt it will be necessary in later centuries to devise some other means of producing aluminium.

The Paley Report attaches the words "reserves inadequate" for many metals, such as chromium, copper, zinc, lead, nickel, and tungsten. These are only examples, but it must be remembered, as already mentioned, that this report refers mainly to the next twenty-five years, and so it seems certain that more and more attention will have to be paid to the resources available from the sea.

Two important materials are already obtained in large quantities from the sea. In the case of magnesium it is estimated that 4,000,000 tons of magnesium are normally present in each cubic mile of sea water. Magnesium is already being extracted from the sea in commercial quantities in Great Britain and may be expected, as development continues, to provide structures of greatly increased strength and reduced weight as compared with what is available to-day.

The other important material already being obtained from the sea is iodine. In *The Sea Around Us* it is referred to as "the most mysterious of all substances in the sea."

I have tried to indicate some of the problems which will have to be solved by engineers in the space of 2000 years. It seems reasonable to assume that we have reached a stage in the development of scientific knowledge which can form a basis for future advance with a diminishing reliance on the principle of trial and error. Thus advances will be made as the result of working out methods of which the final conclusion can be predicted with reasonable accuracy if only materials with the necessary characteristics to make use of the new methods can be produced. It would seem, therefore, that the present generation can feel that it has not merely a great opportunity, but a great responsibility, to start now to develop methods which will make it possible for the progress of man to continue when the resources at present available have become exhausted. Failure to commence development on these lines within the next fifty or hundred years would mean that life on this planet within 2000 years might well deteriorate to a level much lower than that existing to-day. This closing thought is one which above all I wish to impress on the young engineer to-day.

I wish to acknowledge the great help I have received from Dr. S. Main in collecting data and preparing notes for me. I also thank Mr. E. W. Colbeck for suggestions he has made to me and similar thanks are due to Mr. H. S. Peiser.

Fifty Years of Undercarriage Development

No. III—(*Continued from page 278, August 28th*)

In this account of the evolution of the undercarriage mention has been made of the various phases which might be considered to have preceded the advent of the gas turbine. This part concludes that era with a description of the liquid springing units developed by Dowty. It then notes the influence of the gas turbine on undercarriage geometry as contributing to the general adoption of the tricycle suspension in this country and it goes on to consider the factors which dictated the need for multiple-wheeled suspensions.

Liquid Suspension

THERE had been no successful application of the properties of liquid in compression prior to its use in undercarriages by Dowty Equipment, Ltd., during the last war. Largely because of Bridgman's published work in "The Physics of High Pressure," the purely physical properties exhibited by fluids under high pressure had been made available. The task of harnessing in a suspension unit the compressive properties of liquids as a spring whilst at the same time making the same volume of fluid serve as a dashpot medium raised several engineering problems, but none so great as that of effecting a seal. For such a gland had to prevent almost absolutely any loss of fluid under a pressure exceeding 60,000 lb per square inch without exerting excessive friction loads on the rod, and it had to have a reasonable life. Hitherto the simultaneous gratification of these demands by a seal had not been essential, and no such gland had been evolved. This, then, was the major problem confronting G. H. Dowty's conception of a "liquid" sprung suspension unit in 1939, and the seal subsequently developed by his company* is illustrated in Fig. 21. The arrangement forms a special case of the principle of the unsupported area. In this design the pressure of the fluid acts upon the whole area of the gland ring (area A), creating an axial load on the gland washer, the area of which is less than that of the gland ring by the area of the four dowel pin-holes (area a). It follows that the gland washer being made of a fabric reinforced synthetic rubber consequently exerts a radial pressure upon the piston-rod greater than the internal fluid pressure by an amount proportional to the ratio $a/(A-a)$. Thus any desired back pressure from the gland can be obtained by fixing this ratio accordingly. It is shown by Bingham[5] that for any given material there exists from weight considerations an optimum maximum oil pressure which for D.T.D. 331 is approximately 60,000 lb per square inch.

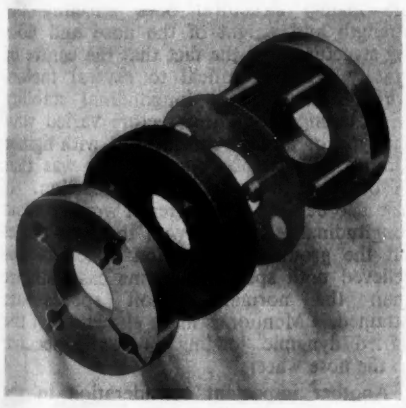

Fig. 21—Dowty "Liquid" Spring Seal

A simple cantilevered system employing liquid suspension, and typical of such installations, is that illustrated herewith (Fig. 22). On admitting the sliding member into the cylinder, the volume of the fluid is reduced by the volume of the rod, and the load displacement curve is roughly linear. Apart from this work, which is stored as potential energy and which has to be dissipated during the recoil stroke, additional energy is dissipated by the transference of fluid through apertures or valves in the piston head and rod, the piston head acting solely as an orifice plate whilst locating the rod.

The form of levered suspension system, developed by Dowty, is one which lends itself particularly to the application of "liquid" suspension because of the extent to which the suspension unit can be compacted. Our illustration shows a Dowty nose wheel leg (Fig. 23) which is typical of this system, but has a modification to permit castoring. The wheel is carried by a lever pivoted to the pivot bracket, which can rotate in the main leg in journal and thrust bearings. The shock absorber is pin-jointed between points on the wheel lever and the pivot bracket, and the action is clearly evident from the drawing.

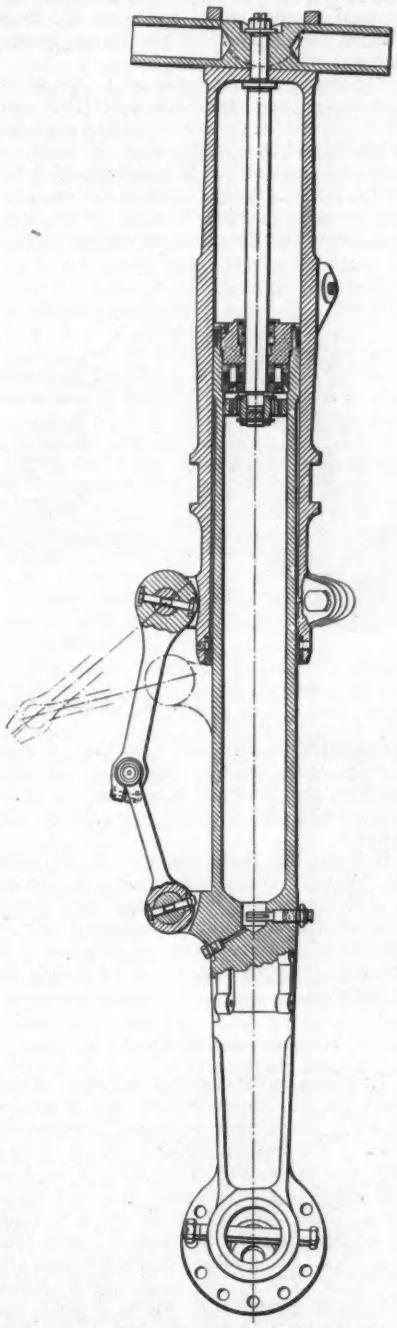

Fig. 22—"Liquid" Sprung Cantilevered Unit

By floating the piston and cylinder in this manner they are subject only to axial forces and are thus relieved of fore-and-aft and largely of transverse bending loads. It will also be realised that in this form of suspension the loads resulting from the spin-up drag are reacted as axial forces in the capsule.

The overall saving in the length of leg clearly depends on the leverage it is practical to adopt. With an advantage in the order of 2·1, as suggested in the unit, the vertical dis-

* British Patent No. 539,966

placement of the piston is reduced to half that of the wheel. Thus, comparing the system with a conventional leg of the same wheel displacement and regarding the capsules as being plain springs, it will be noted that by using a spring of twice the rate in the levered system, both legs would trace the same wheel load displacement curves. Due to the high pressures involved, and the influence of volume of the capsule, it is not difficult to design a "liquid" capsule to operate with an increased "rate" on a shorter stroke, and yet to dissipate the required proportion of energy in the cycle without greatly affecting the normal length/diameter ratio.

The special requirements of a nose wheel unit have been discussed by Orloff and others, where the particular loading case, due to pitching of the aircraft about its radius of gyration is discussed. This case can give rise to the worst loading condition on the nose leg, and as the pitching velocities are generally of a low order, the oil in an oleo-pneumatic unit contributes little to the reaction. Consequently, as the reaction depends on air compression, the efficiency of the unit is much reduced and high reactions can subsequently develop.

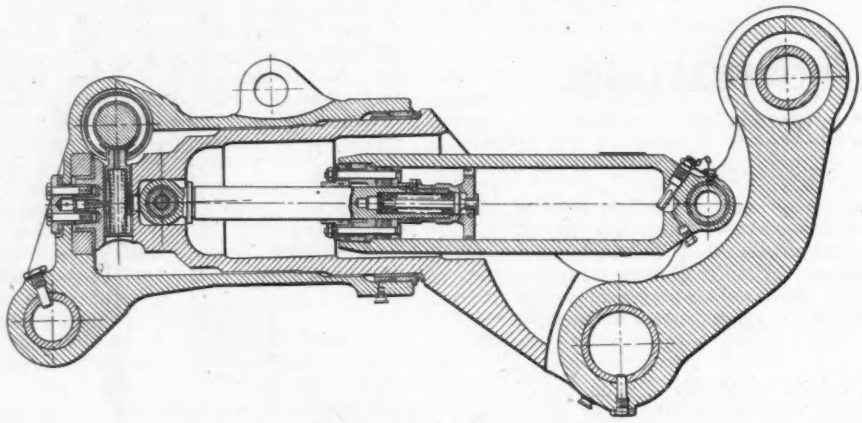

Fig. 23—"Liquid" Sprung Levered and Castoring Unit

It is for this particular circumstance that the "liquid" compression unit again serves to advantage, for it offers a near linear reaction characteristic, independent of the velocity of closure. It is also claimed that shimmy damping can be more easily incorporated.

Production of Cylinders

The mass production of cylinders which make up the oleo-pneumatic unit gives rise to many machining problems, particularly when at the beginning of the last war such a need first arose, and demanded the application of new or modified techniques and equipment. Such cylinders can be up to 5ft long, up to 6in bore, and in places no more than $\frac{1}{16}$in thick. Being subject to internal pressures of up to 3000 lb per square inch, piston clearances greater than about 0·004in can cause the rings to extrude, and, if less than 0·001in, friction forces arising from the reaction of the piston on the cylinder walls, particularly at the moment of touch-down when the cylinders are deflected, might inhibit the telescopic action entirely. The task of maintaining parallelity and freedom from ovality needs no emphasis.

Furthermore, all circular and helical tool or grinding marks seriously shorten the life of the glands or piston rings, and honing and lapping processes are essential to obtain as near an optical surface finish as is practicable. Generally speaking, the cylinders are machined from tube stock of very high-tensile nickel-chrome steel.

During the war, with semi-skilled labour, it was usual to rough finish the stepped outer and inner profiles with full-length traverses successfully working from the largest diameters down to lengths containing smaller diameters. This procedure has also the advantage, although only light cuts were employed, that the maximum amount of metal was available for the rigidity of the work during machining, and consequently internal stresses leading to ovality were minimised. To ensure the best conditions for concurrency and parallelity, extensive use is made of steadies and wide-faced chucks.

Boring presents its own problems as the ratio of the diameter to length of the work often enforces a compromise with the rigidity of the boring bar which can be accommodated. The boring bar is usually supported by a bush in the hollow headstock. Cutting speeds as low as 90ft per minute are typical with finishing cuts no greater than 0·01. In certain cases, mandrels have to be used to prevent distortion due to holding.

Machine tools have been developed for the honing operations in which one or more cylinders are treated simultaneously, the honing head being reciprocated whilst the work slowly rotates.

Very fine limits and finish are required on the Dowty liquid spring components, but it is to their advantage that not only are the lengths much shorter, but the cylinders are much thicker because of the very high pressures involved. In some cases, however, the limits are controlled to 0·0002in. The cylinders and piston-rods are made from S.99, which is an 80/90 U.T.S. nickel-chrome steel. It is of interest to note that at a pressure of 50,000 lb per square inch there is a perceptible increase in the volume of the cylinder amounting to about 1 per cent. Chip breaking tools are used extensively by the company in boring operations which, by the swilling action of a copious lubricant, enable a larger and more rigid bar to be employed.

Speeds of 200ft per minute, with cuts of $\frac{1}{4}$in and a feed of 0·07in, are common, in spite of the extremely tough nature of the steel. The tip includes a proportion of titanium carbide. The glazing and burnishing tendencies of these steels necessitate frequent resharpening, which can be as often as every six cuts.

Post-War Development

The advent of the jet engine exercised a determining influence in this country towards the adoption of the nose wheel tricycle suspension. Although it had clearly superseded the tail wheel arrangement in many American wartime civil and military piston-engined aircraft, practically all British aircraft in this category, with the exception of the "Albemarle," had retained the tail wheel until the close of the last war. The landing and handling characteristics of tail wheel aircraft—although there were again important exceptions—were such that it was practicable and therefore advantageous to attempt a fully stalled landing. Its rolling attitude was, consequently, more nearly that of the fully stalled condition and both the landing speed and the landing run were the lowest possible. Furthermore, with the tail wheel being close to the ground, it represented the lightest overall landing gear arrangement. It is not possible here, however, to examine all the factors involved in the relative designs of the two systems.[6] There do arise, however, two fundamental advantages when placing the centre of gravity of the aircraft forward of the main wheels. In the first case, it will be realised that the aircraft becomes inherently directionally stable, and in the second case, the main wheel landing reaction being aft of the centre of gravity tends to reduce the angle of attack of the wing and thus frustrates the tendency of the aircraft to gain height after a bounce. These factors assume their full worth when landing under conditions of restricted visibility. Conversely, the tail wheel aircraft is inherently unstable directionally, and in a semi-stalled landing with a vertical velocity of descent, the main wheel reaction increases the angle of attack and can cause the aircraft after acquiring height to become fully stalled above the ground. This situation can, unfortunately, readily arise in crosswind conditions, and, excluding extreme cases if the landing attempt is not abandoned, there follows most undesirably, first intermittent applications of engine thrust until such time as the aircraft is finally established on three points, after which ensues a more prolonged struggle with rudder and brake to prevent the aircraft from ground looping, or swinging off the runway. The much higher landing speeds, particularly of swept wing military jet aircraft and their inherently poorer handling and thrust response characteristics in this speed range, had already seriously aggravated the consequences of an error of judgment when landing and the need to eliminate the above conditions needed no emphasis. Besides these two major advantages can be added the ability to use higher braking torques and greatly improved taxi-ing characteristics. One disadvantage—that of higher landing speeds and poorer aerodynamic drag braking—can thus be compensated by the above factor. Its other disadvantages are mainly structural ones affecting the strength and weight of the nose and nose leg structure, and the fact that the centre of gravity becomes critical to several factors which determine the longitudinal stability when taking off. These factors varied with the type of aircraft considered; with fighter aircraft, for instance, one problem was that of obtaining a sufficient nose reaction. It can also be shown that aircraft would remain longitudinally unstable with the nose wheel off the ground, a condition which is not relieved until speeds—in some cases higher than the normal take-off speeds—are attained. Mention is made elsewhere of the varied dynamic loading problems peculiar to the nose wheel.

Another important consideration in the layout of jet aircraft was the need to avoid obliquity of the jet thrust to prevent surface

damage to the runway and also to improve the early take-off characteristics. The power unit has tended in yet another way to influence the design of the leg structure, for in removing the need to provide propeller-tip clearance it can be that the height of the aircraft is solely determined by the functional requirements of the legs. In this connection the use of the articulated (or levered) systems for main leg design may make a valuable contribution.

With the evolution of the monoplane and the adoption of the retractable telescopic leg it was not long before the combined influence of wheel loading, wheel size and tyre pressure forcibly raised the problem of permissible ground loading pressures. Following tests with the "Ensign" airliner in 1937, which had a leg load of 20,000 lb, it was concluded that such aircraft could not be continuously operated on grass surfaces, which were then universal, if tyre pressures were much in excess of 35 lb to 45 lb per square inch. Thus the need for paved surfaces had arrived, the first concrete runway in this country being completed in 1939.[7]

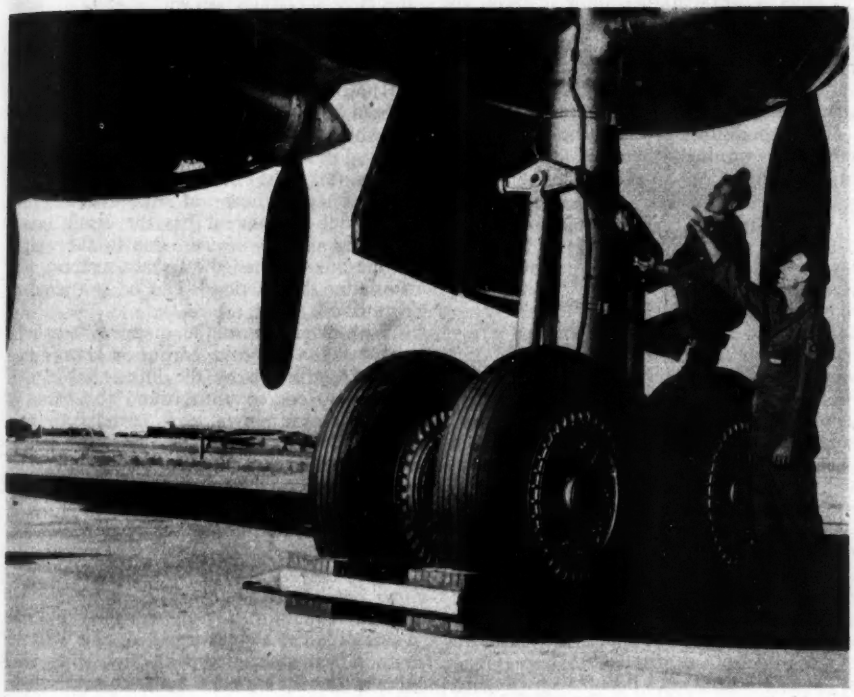

Fig. 24—Bogie on "Convair B.36"

Since then, however, with the seemingly inexorable growth of aircraft, runways have had to become ever longer, deeper and wider. They have grown deeper because leg loads have increased from that of the "Ensign" to values of 60,000 lb upwards to 135,000 lb, which was the leg load of the "Brabazon" Mk. I; for reasons leading to increased take-off and landing speeds and to provide the necessary margins for asymmetrical thrust and for blind flying conditions at take-off they have grown larger, and principally for this latter reason have grown wider also. From 800 yards they have stretched to 3000 yards, there are many runways now 100 yards wide, and the tendency to deepen is explicit in one particular construction in the United States where a single slab concrete runway has been laid 2ft 6in thick.

In so far as the loading effect is concerned in this problem of airfield construction only the depth is conditioned by leg loading. While the depth and cost of construction had orginally increased in a manner more or less proportional to wheel load with medium tyre pressures, the process of matching the airfield to the aircraft was hardly questioned and it appears that most of the airfields built during the war enjoyed this relationship.[7] Unfortunately, above a certain combination of tyre pressure and wheel load this ratio changes very unfavourably and to accommodate the present characteristics of certain recent military and civil aircraft the cost of using established methods of design and construction had risen prohibitively. Several papers on flexible and rigid runway construction in recent years in which some experimental methods of reinforcing runway were also reviewed had stressed the formidable if not impracticable task of providing a satisfactory pavement for the single-axle loads which designers had once contemplated.

In so far as future construction is concerned it has been expressed by authorities, both in airfield and undercarriage design, that such aircraft be not land based on the first case.[8]

There are also those who advocate the adoption of the swivelling undercarriage so that aircraft might operate from uni-directional runways. The economy arising from such a layout is apparent, but in spite of the fact that such undercarriages have been under development for some years and, it is stated, have presented no serious engineering problems, or structural handicap, they have made no appeal to airline operators. It may be noted also that thrust augmentation by the use of rockets and rocket motors, both of which have a characteristically high thrust/weight ratio, is being most rigorously investigated and remarkable shortening of the take-off distances have been demonstrated, both here and in America. Experiments with negative thrust devices, such as tail parachutes, rockets and the reversal of main engine thrust, either through the propellers (already in common use) or by deflection of the jet effluent, suggest that the landing run also can be effectively shortened.

However, the immediate task which arose immediately after the war was how a new class of both civil and military aircraft of from 100,000 lb a.u.w. could utilise the great number of existing runways. In this country it is now clearly evident the bogie undercarriage, in most cases of twin tandem arrangement, has provided an interim solution.

On a given pavement there exists a range of permissible contact area, i.e. leg loads on a single wheel of given diameter for each of which a limiting tyre pressure must be observed and such that increasing leg load must be accompanied by decreasing tyre pressure, the tyre pressure being equal to the contact pressure.

Thus, to accommodate on most existing airports the larger leg loads of several recent aircraft on a single wheel would require a lower tyre pressure and particularly in the range of pressures 40 lb to 90 lb per square inch, an inordinately increased wheel size would result. This effect of tyre pressure on the weight diameter and bulk of the wheel and tyre is illustrated by Cooper.[9] He shows two groups of tyres, one group carrying 16,000 lb at 49 lb and 100 lb per square inch respectively, and another group carrying 8000 lb at 43 lb, 70 lb and 150 lb per square inch respectively, so that two of any of the smaller wheels could replace either of the larger tyres.

Thus, solely from runway loading considerations an ideal multiple-wheel undercarriage would use the highest permissible tyre pressure with the necessary contact area so distributed between a number of wheels that each acted upon the concrete independently.

The stress distribution resulting from a multi-wheel arrangement depends primarily upon the wheel spacing and is also largely influenced by whether a flexible or rigid pavement is used and hence by the subsoil, and the materials used. One analysis has been published by Cooper.[9] Two official schemes of runway classification exist based upon the isolated single-wheel load with a specified tyre pressure which can be used continuously without runway damage. In conjunction with such existing classification an equivalent single-wheel load has been defined, being the isolated single-wheel load which would cause the same deformation as the group of wheels it replaces when using the same tyre pressure, Due to the complex nature of the factors involved in runway deformation a vast amount of research work is currently in hand in order to establish effective data.

Provisional estimates indicate that a value of about 0·5 is being achieved.

An early recognition of these problems had already resulted in the use of twin wheels or double-twin-tyred wheels on each leg. The "Brabazon" Mk. I originally had this arrangement also, whilst the American "B.36" had only a single wheel on each leg, and now has that shown in Fig. 24. Both these aircraft exceed 300,000 lb weight and it has since been necessary to modify their undercarriages. In the case of the "Brabazon" a twin tandem unit had been developed. The upper limit for single-wheeled aircraft now stands at about 100,000 lb, assuming tyre pressures of between 90 lb and 100 lb per square inch.

Runway considerations aside an even more urgent problem had become manifest. Using the highest tyre pressures about which reliable data (about 90 lb to 150 lb per square inch) has been obtained, some high-speed aircraft,

because of their low wing thickness/chord ratio and swept configuration, would not be entirely free from embarrassment in housing any single axle installation without weakening the basic wing structure, or in some cases of enveloping it at all. With such machines, where the engines occupy the wing roots, the undercarriage itself, when retracted, must conform with the profile (outboard) of a relatively thin wing, and only an articulated bogie with a multiplicity of small wheels could lend itself satisfactorily to such stowage. Thus, although the design was first conceived in 1942 as being a probable concession to airfield requirements, it was soon to be dictated by structural ones, and events, if in fact fortuitous, have proved it a notable advance in the evolution of undercarriage design. For not only has it proved a happy solution to both problems, but it enables an overall reduction to be achieved in the undercarriage/aircraft weight ratio, which was not expected. The weight advantage derives from the saving in weight of a number of small wheels to that of an equivalent single wheel, the difference substantially outweighing the extra weight of the strut, beam, axles and dampers.

That the balance realised should be a significant one is not a little due to the ingenuity with which the manufacturers have met the new landing, taxi-ing, braking and stowage problems introduced.

Dynamically, there are both advantages and disadvantages inherent to multi-wheel undercarriages. A fundamental problem of which some factors are discussed below arises from the tendency of the bogie to porpoise when initiated by influences redisposing the static weight distribution. Such oscillations could develop resonant excitations of the leg structure and the need to stabilise the bogie largely governs the design and naturally reflects in the weight and cost.

On the other hand, the polar moment of inertia of four small wheels being much less than that of an equivalent single wheel the spin up drag force on the leg, which is one of the critical bending cases on the leg, is correspondingly less. It is further reduced in twin tandem arrangements by tilting the beam or the plane of the wheel axles so that spinning up takes place in two stages.

By suspending the beam when unloaded in this way closure of the "anti-hop" dampers during rotation of the bogie has been effectively employed to varying extents in some designs in shortening the required stroke of the main leg. This use of the hop damper also restricts the tendency of the front wheels to slam upon the ground, a characteristic occurring as a result of the anti-clockwise rotation of the beam on initial contact. As the downward tangential velocity of the front axle must be in addition to that of the aircraft, it follows that its vertical contact velocity can approach twice that of the machine. This rotation is accentuated by the couple set up by the spin up drag of the rear wheels, and these forces together can lead to overload on the tyres.[10]

Spacing in twin tandem wheel arrangements also governs the torque on the structure and the side load on the tyres imposed during ground manœuvres. The worst conditions can be appreciated with the aircraft turning on one leg. Here each tyre experiences a force almost entirely axial without much rolling action, consequently distorting its walls. At the same time, as the front and rear tyre reactions are in opposite directions the whole structure is subject to considerable torque.

The results from a scale model investigation of such manœuvring loads on the bogie undertaken by the Ministry of Supply in 1948 have been published.[11] The paper refers to three factors governing the tyre loads. A particularly critical one is defined as the cornering angle which might be described as that angle through which the axle of the wheel must be turned to lie along the radius of the turning circle, this angle being zero when the wheels roll without scrubbing. The angle therefore increases with longitudinal spacing of the tandem wheels for any given radius of turn and it increases for a given wheelbase with decreasing turning radius. The results show that the side force coefficients on the tyre, which are directly proportional to the torque on the leg, increase rapidly with increases of cornering angle and it is suggested would reach a maximum at a cornering angle of 25 deg.

Subsequent tests upon a full-scale "Comet" installation follow closely the results of these model tests. During later full-scale tests on a Mk. 2 "Brabazon" bogie it was observed that although the tyres showed considerable creasing no permanent structural damage to the wall was detected.

This condition governs the permissible minimum turning radius of the aircraft,

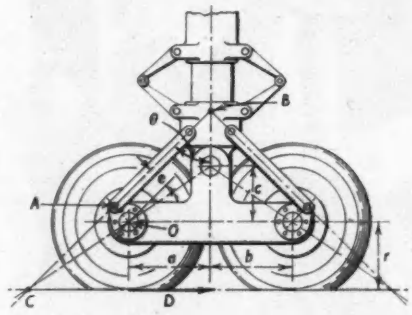

Fig. 25—Diagram of Bogie and Tricycle Geometry

and a desirable value is considered to be that which gives a side force coefficient of about 0·25 to 0·3.

The first multi-wheeled installation in this country was made by Messier Aircraft Equipment, Ltd. (now Electro Hydraulics, Ltd.). This experimental and non-retractable installation was fitted to a "Lincoln" aircraft and landing trials commenced in 1947. It served to illuminate certain dynamic characteristics and in particular forcibly revealed one reason why the beam pivot should be on the plane or as near the wheel axle plane as possible. A landing occurred in which a particularly high drag reaction developed which actually passed below the pivot, whereupon the beam was swung backwards and the rear wheels jambed in the leg structure.

Before describing the principal details of the more important designs which have since been made, some other important factors which determine the load distribution on the wheels might be noted. Thus, statically (Fig. 25), the load distributed upon the main legs and nose wheel will be inversely proportional to their distances from the centre of gravity of the aircraft; but in the dynamic case under steady conditions with a constant braking force, there is, according to the magnitude of H, a transference of weight from the main legs to the nose wheel amounting to $\mu H \cdot W/L$, where μg is the steady deceleration.

A more serious transference of weight is that occurring between the bogie axles themselves. In this case it will be noted from the diagram that the overload on the front axle amounts to $Wh\mu/2L$.

The difference in polar moment of inertia of the aircraft and the bogie gives rise to a transient case in which the bogie transference is completed with the full static load on the leg. Were these conditions on the bogie allowed to develop the overload on the front tyres could exceed that permissible whilst the rear wheels would lock due to the relieved load. Two methods of minimising or eliminating load transference between the bogie axles were examined by Collinson[12] in 1949. One method discussed involved disposing the wheel axle so that $a>b$, and in this way in conjunction with a suitable value of h accepting a permissible static overload on the rear wheels in order to reduce the dynamic overload on the front tyres.

The other method examined by Collinson related to the use of compensating linkage by which the bogie beam is almost entirely relieved of the brake reaction. This principle is, in fact, the method which has been adopted on most of the installations described, although it has the disadvantage of being slightly heavier, due to the weight of the linkage than the former method if in the latter the overloads can be restricted to permissible values.

With reference to the diagram it will be noted that the brake torque is transmitted to rigid structure by the link AB which is aligned to cut on the ground the plane of the axle and pivot axes produced, this point being the instantaneous centre of the brake installation AO. As the braking drag ground reaction also passes through this point its action and the force in the link can have no moment above the bogie pivot, i.e.

$$\frac{Dra\cos\theta}{l} - cD - \frac{cDr\sin\theta}{l} = 0.$$

This equation is only satisfied by one value of r, i.e. a given leg load, and with the tyre radius associated with any other load the system cannot be fully compensatory. The out-of-balance force is again dependent on the height of the pivot above the axles, but it is shown to be generally of a small order. The linkage shown diagrammatically (Fig. 25) is, in fact, basically similar to the system on the "Victor" aircraft.[13] References to the systems adopted on other installations will be included in their descriptions.

Several new braking problems arise with bogie wheel undercarriages. As it may well be a requirement with all these heavy aircraft to be able to maintain a constant maximum braking torque consistent with the wheels rolling without skidding, automatic braking mechanisms incorporated in each wheel have been developed and are undergoing evaluation. The need for these follows from the fact that the dynamic factors which disturb the weight distribution on the bogie wheels, together with ground friction coefficients which may be different for each wheel, necessitate a momentary relaxation of brake pressure if the affected wheel or wheels are not to skid, and its almost instantaneous restoration when rolling is fully re-established. The development of two proprietary units was described in a recent article in THE ENGINEER, October 3, 1952, page 460. To interrupt the fluid supply to the brakes they employ the relative changes of angular velocity of the landing wheel and an inertia wheel driven directly from it, which occurs when rates of change of landing wheel speed exceed the optimum. They are capable

of completing about sixty braking cycles per minute.

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The Supply of Technical Officers for the Army

By LIEUTENANT-COLONEL FREDERIC EVANS, M.B.E., T.D., M.A. (Cantab.)*

The kind of training necessary for a technical officer in the Army is reviewed; particular attention is given to two new ventures, the establishment at Welbeck Abbey of a school to take boys of sixteen and the method of obtaining a Regular Commission direct through National Service officer training respectively. The requirements which applicants must fulfil are given in some detail.

It is an obvious truism that modern warfare or preparation therefor is becoming every day more and more a matter of technology. This implies an increasing need for officers technically trained and qualified, but these officers have to be soldiers as well and to have or acquire those qualities necessary for the leadership of men under conditions of great trial and stress. They have also to see their technical duties in relation to the general tactical and strategic plan and in association with the operations of other arms of the Service, as well as with those of the Royal Navy and the Royal Air Force. This combination of technical qualifications and ability with their application in terms of men at war is not a common one in technicians as at present trained. Too many of them who may wish to serve in the Army are keenly interested in the technological aspects of their duties, but they do not always realise sufficiently the need to develop the qualities of leadership and to be concerned with soldiering as such.

This somewhat narrow point of view among many of those technically educated is, to some extent, inherent in the present system. Scientific and technological courses are exacting and strenuous, and the attention of the student tends to be, almost of necessity, directed solely towards the subjects of study, leaving little energy and opportunity for a consideration of the wider aspects of their work, for a greater appreciation of the culture of our civilisation and for the need to acquire the gentler arts of living. For technical students "life is real and life is earnest" to perhaps a greater degree than for students following any other course of study. Yet the greatest technicians have been also men of the world and often of high stature in the deeper philosophies of culture and life. Those responsible for technical education have long been concerned with this weakness in their system. At the annual conference of the National Institute of Adult Education, held at Trinity College, Cambridge, September, 1952, it was announced that a new research project—an inquiry into the relation of vocational and non-vocational studies in the education of the technical student—was to be embarked upon under the sponsorship, jointly, of the Institute, the Association of Technical Institutions and the Association of Principals of Technical Institutions. The aim is to liberalise technical education and to prevent it becoming (or continuing to be) a rigid specialisation divorced from other and wider fields of knowledge. The help of the Kellogg Foundation in this work is being sought.

This is a step in the right direction in the interests both of a wider outlook among technologists and in the provision of leaders with vision for the needs both of civilian life and of the fighting Services. At present, the overall control of armies is almost exclusively (and necessarily) in the hands of the all-round man with the general rather than the specific outlook. When the training of our technicians enables them more surely to have the wider outlook as well as the technological skill, then we shall see more of them holding general commands, and that will be all to the good. For instance, as was so often seen in the late war, the General Officer Commanding had to act politically, deal with high-ranking statesmen and public officials, and be something more even than a good soldier. We cannot plan the training of our future leaders on too wide a basis of general culture and of a critical knowledge of affairs. Furthermore, there is the need, in technical officers, of the ability to be able to interpret to the research scientist and the inventor the needs of the soldier in the field. In short, the technical officer has to be both a soldier and a technician, and this demand upon him cannot be adequately met (only in exceptional cases) by most of the present-day methods of training technicians. In addition to the above-mentioned move in civilian circles for those responsible for technical education to "liberalise" their courses the more, the Army, in its schemes for the recruitment and the further training of technical officers, is aiming to do much the same thing with, as is appropriate, greater emphasis upon training for leadership. Here, perhaps, the Army plan can be discussed in some detail.

Most regular officers start their officer training at the Royal Military Academy, Sandhurst, between the age of eighteen and nineteen. Here about half the working time is spent on academic subjects, and the more scientifically inclined are prepared for the university qualifying examinations of Cambridge or London Universities. Some twenty go yearly to Cambridge, where they follow a two-year course and are expected to pass the B.A. Honours Degree in Mechanical Sciences. The remainder of those scientifically inclined go to the Military College of Science, Shrivenham, where they undertake a two or three-year course leading to the external B.Sc. Degree in General Science or Engineering of the London University. There are also many opportunities for post-graduate work in the Army. There is research to be done at Shrivenham, and there are numerous long courses which are designed to train specialists for the technical branches of the Army. On these courses officers work partly at military schools and partly on attachments to civilian firms. There are courses in civil, electrical and mechanical engineering, railways and shipping, survey, wireless, radar and petroleum engineering, to mention a few, and many of these courses enable the officer to qualify for associate member status of the appropriate professional institution. Such officers may, at suitable stages in their Army careers, be accepted not only for the technical staff course at the Military College of Science, but also for the general course at the Camberley Staff College.

The Army needs more officers in its technical branches and there are two new ventures in this connection. The first is the establishment at Welbeck Abbey of a school to take boys at the age of sixteen and to prepare them for the more scientific courses at Sandhurst. It is felt that this will open the Army career to many boys of excellent quality who would not otherwise have been able to consider it. The second venture is the method of obtaining a regular commission direct through National Service officer training, followed by a degree course at the Military College of Science.

So far, the emphasis has been on the scientific education of the officer, but he has also the normal Sandhurst military education or (in the case of the Shrivenham direct entrant) that obtained under National Service. Either before or after his university education he undergoes the normal training peculiar to his branch of the service at, for example, the School of Military Engineering or the School of Signals. He then begins his service as a trained officer doing regimental service with a unit of his corps, and at intervals throughout this service he returns to regimental duty. In later life he is not restricted only to technical or scientific employment and the highest ranks are open to him as a commander or staff officer. (Here we have a definite plan to produce technical officers suitable also for general commands.)

Thus we see the future young officer of the Army's technical branches starting, perhaps, at Welbeck Abbey at the age of sixteen and then going on to Sandhurst at eighteen, or going to Sandhurst direct or perhaps coming in through the new Military College of Science entry. He does the training peculiar to his branch of the Service at its own school and completes his academic training by taking a Cambridge or London University degree. He then serves as a regimental officer, and can make a career as such, or he can specialise on any one of the long courses leading, in many cases, to membership of the appropriate professional institution: whatever he does, the higher ranks are open to him in the same way as they are to any other officer, and he is in no way restricted by being only a specialist because this training includes the evolution of those other qualities of mind and outlook which are necessary in the control of large bodies of men and, ultimately, in the conduct of any great campaign involving geographical, ethnical and political factors.

It will be appropriate at this stage to say something more about the Welbeck College scheme. The following information is almost identical with that given in the College prospectus.

The object of the College is to provide suitable candidates for regular commissions in the Technical Corps of the Army. A free education will be offered to suitable boys of about sixteen years of age who wish ulti-

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mately to go to the Royal Military Academy, Sandhurst. Boys who would normally have to leave school at that age in order to earn their living are given special consideration.

While Welbeck College is intended primarily to produce officers for the Technical Corps, the Army Council may, in special circumstances, permit a boy to be commissioned in one of the other arms.

The boys will remain at the College for two years, and as the entrance age to R.M.A., Sandhurst, is from eighteen to nineteen, boys will enter Welbeck between fifteen and three-quarters and sixteen and three-quarters years of age. Some flexibility will be allowed in this.

An applicant must fulfil three requirements.

First, that his headmaster should forward a testimonial certifying that the candidate is suitable on the grounds of character and that he is likely to be suitable for entry to R.M.A., Sandhurst, between the ages of eighteen and nineteen.

Second, that he should have reached the educational standard of the General Certificate of Education with passes at ordinary level in mathematics, science and one other subject ; or in Scotland, that he should have completed the fourth year of a senior secondary course, with passes as above on the lower grade of the Scottish Leaving Certificate or University Preliminary examination. If for any reason the applicant has not yet taken the examination, his headmaster's report on his attainment will be considered, but an education test may be imposed. Special consideration will be given to boys studying at technical schools or colleges, full or part time.

Third, acceptance by an interviewing selection board consisting of four members, including a headmaster and a representative of the Local Education Authority. The board will visit specified centres in the United Kingdom and applicants will be informed where they are to present themselves. When visiting Scotland and Wales a Scottish or Welsh headmaster respectively will also serve on the board. The expense of third-class rail or omnibus fares in excess of 7s. 6d. incurred by candidates in travelling from normal place of residence to the place of interview will be refunded.

A medical examination will be arranged locally at the time of the interview.

Fifty boys will enter in September and twenty-five in January each year. Applications must reach the War Office by January 10th for the September entry and by June 10th for the January entry. Selection Boards will be held in February/March and July respectively.

On the application form (obtainable from the War Office) parents and guardians will be required to sign an undertaking that the boy, if accepted for the College, will be regarded as a candidate for the Royal Military Academy and, if successful, will serve at least five years as a regular commissioned officer on the active list.

The College will be run on the same lines as other boarding schools. Membership of the Combined Cadet Force contingent will be obligatory. General subjects, including English and a modern language, will be taught, but the emphasis in instruction will be placed on mathematical and scientific subjects. All boys will receive practical workshop instruction in wood and metal work, and it is hoped to include music and art as optional subjects. Religious instruction (undenominational) will be given. Physical training will be a regular part of the syllabus.

Boys who satisfactorily complete their two years' course of studies and are reported on by the headmaster as suitable, will enter the Royal Military Academy without further examination or test. The short period of service in the ranks which is obligatory for all entrants into the R.M.A. will be carried out before joining Sandhurst. From Sandhurst, the opportunities to undertake a degree course at Cambridge or at the Military College of Science will, of course, apply.

The prospect is offered, therefore, of a complete engineering or scientific education, including a university course, as well as the assurance of a full career and of a qualification recognised by military and civilian authorities alike. According to Press reports, the flood of applications for the pre-Sandhurst course at Welbeck Abbey has been remarkably good for the first entry.

Since it is hoped that this article will reach the eyes of technically qualified men who may themselves be eligible and interested, or who may have charge of the training of technical men, the outline of the Scheme for Direct Entry for Regular Commissions in the Technical Arms by way of the Military College of Science, Shrivenham, is also given, almost *verbatim*, below.

The following qualifications are required for acceptance as a candidate under the Military College of Science scheme :—

(1) *Nationality.*—Must be a British subject or citizen of the Irish Republic, and the son of British subjects or citizens of the Irish Republic.

(2) *Age.*—Must, if school boys, be between seventeen and a half and nineteen and a half on September 1st of the year in which they are called up for National Service.

If serving National Service officers or men, they must be between eighteen and a half and twenty and a half on September 1st of the year in which they enter the Military College of Science.

(3) *Educational Qualifications.*—Applicants must satisfy the minimum entrance requirements of London University, and also have passed or gained exemption from the Intermediate Science examination of that university in the appropriate subjects, to obtain approval of candidature for B.Sc. (Gen.) or B.Sc. (Eng.) Degree examinations. As the B.Sc. (Gen.) Degree covers studies other than those required by the Army, the three passes stipulated for the Intermediate examination for this degree must be taken from the following subjects :—

(i) Pure mathematics ; (ii) applied mathematics ; (iii) physics ; (iv) chemistry ; (v) mathematics (pure and applied) one subject, but not in addition to (i) or (ii).

(4) Candidates may be either schoolboys, National Service officers or National Service men.

(5) *Method of Entry.*—The method of entry for a schoolboy applicant will be as follows. He must :

Pass the Regular Commissions Board ; be called up for National Service ; carry out basic training in the Arm of his choice, enlisting in September ; go through the Officer Cadet School appropriate to that Arm ; be commissioned as a National Service Officer ; do six months' regimental duty with an active unit of the Arm of his choice ; do a young officer's degree course of two years (general science) or three years (engineering) at the Military College of Science, taking a London University External B.Sc. Degree at the end. The courses will start yearly in September. In addition to academic studies, the instruction will include appropriate military and recreational training, in order to develop powers of leadership; be granted a Regular Commission at the end of his second year at Shrivenham ; on graduation be granted an ante-date of seniority which will align his seniority with that of an officer who has passed through Sandhurst, his exact position being determined by the class of honours he attains.

(6) Entrants already doing their National Service will attend the Regular Commissions Board at the earliest opportunity, and then continue with the sequence at (5) above from the appropriate stage.

(7) Officers will be required to undertake to serve as Regular Officers for not less than five years from the date of their graduation. The War Office reserves the right to dispense with the services of any candidate at any time if he proves unsuitable.

(8) *Rates of Pay.*—Officers will be paid 13s. per day for the first two years of their time at the Military College of Science. On obtaining their Regular Commission, they will be paid the same rate as Regular Officers of the same rank, i.e. 17s. 6d. for Second Lieutenants and 19s. 6d. for Lieutenants. Promotion to Lieutenant will be granted two years from the date to which their Regular Commission is ante-dated.

(9) *Applications.*—Applications and a birth certificate should be submitted to the War Office (AGI(OFFRS)C), Lansdowne House, Berkeley Square, London, W.1, together with either proof of having obtained the educational qualification laid down, or a certificate from the applicant's headmaster showing that he has taken the examination and that, though results are not yet published, there is a reasonable prospect that he will obtain the necessary qualifications.

Applications for the courses should reach the War Office not later than September 1st in each year. Successful applicants will join the Army in September or October of the same year and enter the Military College of Science, Shrivenham, in the following September.

(10) Applications from serving National Service officers and men will be considered at any time, provided it is possible for them to complete (or have completed) six months as an officer before going to the Military College of Science, and that they have the necessary qualifications. Such applications will be submitted through the usual military channels.

There are places for women officers, too, in the Technical Arms. In addition to the normal Regular Commission for women in the Women's Royal Army Corps, it has now been decided that a limited number may be employed for permanent duty with R.E., R.Sigs., R.A.S.C., R.A.O.C., R.E.M.E., R.A.P.C. and R.A.E.C. The qualifications required are :

Royal Engineers.—Education to Matriculation standard. A knowledge of accountancy, a degree in engineering ; a City and Guilds standard, or equivalent, in building or electrical and mechanical subjects is desirable, but not essential.

Royal Signals.—General Certificate of Education at ordinary level, showing passes in English, mathematics, applied mathematics and probably physics as well is desirable.

Royal Army Ordnance Corps.—General Certificate of Education showing passes in :

(1) Four subjects at ordinary level, including English language and mathematics, or (2) three subjects, including English language and mathematics, of which two must be at advanced level.

Royal Electrical and Mechanical Engineers.—An engineering degree from a British university, or any other qualification which is acceptable to the Institution of Mechanical Engineers or the Institution of Electrical Engineers as satisfying the requirements of Sections A and B of the Associate Membership Examination of either Institution, or a degree from a British university in science, provided that physics was included in the final examination.

Royal Army Pay Corps.—Associate or member of either : The Institute of Chartered Accountants in England or Wales ; in Scotland ; in Ireland, The Society of Incorporated Accountants and Auditors, The Association of Certified and Corporate Accountants.

Royal Army Educational Corps.—A degree from a British university, or equivalent qualification, which the Army Council accepts in lieu, or entitlement to recognition as a qualified teacher. Preference will be given to candidates in possession of a diploma of education in addition to a degree, or to those with teaching experience.

These Commissions are Regular Commissions and, broadly speaking, the conditions of service are the same for the women as for men in their own particular section of their Arm, with certain adjustments to scales of pay and pension. A woman has also the right to resign her Commission when she marries.

Here, then, are the opportunities for young men and women who are technically inclined and who seek an active career in company with colleagues enthusiastic in their desire to serve their country and obtain the status of technicians as well as that of Regular Officers in the Army. To many young people, if they learn of the present schemes in time, the prospect is an attractive one. There is real work to do and a variety of personalities and stations to make it very absorbing. The Royal Signals and the Royal Electrical and Mechanical Engineers, especially, require candidates for their Regular Commissions. It would seem that the openings in these and in the other Technical Corps are insufficiently known to educational and technical Institutions throughout the country and to the engineering world in general.

Standard Class "2" Tank Locomotives for British Railways

THE latest addition to the range of standard locomotives to be placed in service on British Railways is a new class "2", 2–6–2, mixed-traffic tank engine. Twenty of these engines have been ordered and the first, No. 84002, illustrated on this page, was recently completed at Crewe works. This first group of locomotives will operate on the London Midland Region on branch line passenger work of the kind at present handled by old 2–4–2 and 0–4–4 tank engines of pre-grouping design.

As in the case of the earlier standard locomotives in service, this one has been designed under the direction of Mr. R. A. Riddles, member for mechanical and electrical engineering, Railway Executive. The parent office for the design was Derby, but component parts were also designed at Swindon, Brighton and Doncaster.

Standard Class "2" Tank Engine

Although this is the smallest tank engine to be built in the British Railways' standard range of twelve types, it incorporates, as far as practicable, all the modern developments in design which have proved themselves on larger engines. The engines have a rocking grate with self-emptying ashpan and a self-cleaning smokebox, and soft grease lubrication is widely used, nipples being arranged in readily accessible groups.

The leading dimensions are as follows :—

Cylinders, diameter and stroke	Two, 16½in by 24in
Wheels, coupled	5ft diameter
Wheels, carrying	3ft diameter
Wheelbase, coupled	13ft 9in
Wheelbase, engine total	30ft 3in
Heating surfaces :	
Tubes	924 square feet
Firebox...	101 square feet
Total evaporative	1025 square feet
Superheater	134 square feet
Grate area	17·5 square feet
Boiler pressure...	200 lb per square inch
Tractive effort	18,513 lb
Adhesion factor	4·7
Weight of engine in working order ...	63 tons 5 cwt

The boiler fitted to the new locomotive is interchangeable with that used on the standard class "2," 2–6–0 tender engine, described in our issue of February 6, 1953, and is generally similar to that used on the class "2," 2–6–0 and 2–6–2 engines of ex-L.M.S. design. The barrel consists of two rings of steel plate, the second being tapered equally at top and bottom. The outside diameter increases from 4ft 3in at the front ring to 4ft 8in at the firebox end. The barrel contains twelve flue tubes and 162 small tubes, the length between tube plates being 10ft 10½in. A Belpaire firebox, 5ft 11in long and 4ft 0$\frac{7}{16}$in wide outside, gives a grate area of 17·5 square feet. All the water space stays are of Monel metal, nutted inside the firebox, while the roof, longitudinal and transverse stays are of steel.

In the relatively large dome there is a vertical grid regulator of normal two-valve design, operated from the cab by external pull rod and a transverse shaft entering the barrel at the base of the dome.

As far as possible all boiler fittings are standard with those used on other standard locomotives. The main steam manifold is placed on the top of the firebox outside the cab and carries all the separate steam valves for fittings ; it is provided with a main shut-off valve also operated from inside the cab. Separate top feed clack valves are mounted on the front barrel at 30 deg. each side of the vertical centre line, discharging the delivery from two live steam injectors on to a tray deflecting the water away from the tubes to the sides of the barrel. A blowdown valve for discharge of sludge is fitted to the front of the firebox, and is manually operated from ground level.

The main frame plates are 1in thick and are suitably stayed with fabricated stays. Horn-blocks are provided for the driving axle, and guides at leading and trailing coupled axles ; they are fitted with manganese steel liners welded and riveted to mild steel backplates, which are in turn bolted to the guides to provide means of subsequent adjustment.

Coupled axleboxes of cast steel have pressed-in horseshoe brasses. Mechanical lubrication is fed direct to the underkeeps, in which a worsted pad feeds the oil to the journal. Manganese steel liners are welded direct to the axlebox guide surfaces. Underhung laminated springs are used, with flat section spring links having means of adjustment by flat cotters for weight and height.

The two outside cylinders have 8in diameter piston valves operated by Walschaerts gear, which gives a travel of approximately 6in in full gear with 1$\frac{5}{16}$in lap and ¼in lead. Two-bar crossheads are fitted. Lubrication of the cylinder and valve chest is from a mechanical lubricator through atomisers working in conjunction with the cylinder cocks. The top slide bars are also mechanically lubricated, and all motion pins, except the expansion link and radius rod die pins, dies and die paths, are soft grease lubricated, the exceptions being oil fed.

In the leading pony truck spring side control is effected by double helical springs. Two spring-loaded friction dampers are used fore and aft of the truck centre to control further the side movements of the truck. Coil springs are used at each end of a yoke to transmit the weight to the axleboxes.

The swing-link trailing truck is fitted with similar friction dampers to those used on the leading truck.

Side tanks of riveted and welded construction, hold 1350 gallons of water and the bunker, which is shaped to give a good lookout when running backwards, holds 3 tons of coal.

As in other standard locomotives, the steam and vacuum brake equipment consists of twin "SSJ" ejectors alongside the smokebox, in conjunction with a horizontal-acting vacuum brake valve and steam brake valve. The vacuum brake control automatically gives a graduated steam brake application on the engine, and the steam brake can be applied independently if so desired.

In order to enable these engines to work push-pull trains under the control of the driver at the other end of the train, vacuum-controlled auxiliary regulator valves are fitted in each steam pipe from the superheater header to the cylinders. The single-seated poppet valves fitted are mechanically operated by linkage from a diaphragm vacuum cylinder. The driver can operate these valves from the compartment at the opposite end of the train by a supplementary train pipe and suitable vacuum controls.

Mobile Instruction Unit for Railway Staff

IN order that members of the carriage and wagon examining staff at out-depots of the Eastern and the North Eastern Regions of British Railways may attend refresher courses under the guidance of a competent instructor, the Carriage and Wagon Engineer, Eastern and North Eastern Regions, Doncaster, has recently installed equipment and working models of the automatic vacuum brake in a converted 49ft bogie saloon coach. By using this coach it will be possible to lecture to the carriage and wagon examining staff in districts instead of bringing them from a wide area to a particular works for a course of interim training. It will enable the staff to be kept informed of new developments and items of equipment which are not yet in general use.

Interior of Instruction Coach

One end of the coach is equipped with seating accommodation and blackboard for lecturing purposes, whilst the other end has washing and toilet facilities. The rest of the interior is taken up by working models and exhibits of the automatic vacuum brake as fitted to all classes of coaching stock. By using an electrically-operated vacuum exhauster to operate the working models, it is possible to demonstrate all aspects of the automatic brake, such as release valves, passenger communication apparatus and guard's application valve.

One model which represents a train of a locomotive and six coaches can be seen in the photograph reproduced on page 301. Although the coaches are necessarily only diagrammatic, reservoirs fitted below are the actual capacity of the train pipe. The vacuum hosepipes, couplings, passenger communication apparatus and guard's application valve are as used in service. With this model the instructor is able to create defects or air leaks to test the examiner's ability in finding and rectifying them, thus examiners gain experience in the quick location of defects under traffic conditions and learn to save valuable time.

Other models include a full-scale working model of an automatic vacuum brake as fitted to bogie coaching stock, and full-size vacuum brake cylinders of the rolling ring and standard sliding-band types sectioned to expose interior details.

Rocket Exploration of the Upper Atmosphere

By ERIC BURGESS, F.R.A.S.

THE Oxford Conference on the use of the rocket for upper atmosphere research, held under the auspices of the Gassiot Committee of the Royal Society, took place at an opportune time just after the Minister of Supply, Mr. Duncan Sandys, had issued his statement on the progress of British guided weapons. If anti-aircraft weapons are developed as he suggested and they might become capable of taking a 100 per cent toll of attacking aircraft, then some other method of delivering atomic bombs to their targets will be required. The answer appears to be the long-range multi-step rocket, but its development depends not only on experience gained from the firing and operation of large rocket vehicles, but also upon accurate knowledge of the conditions and peculiarities of the upper atmosphere through which these vehicles must travel. Although the Oxford Conference indicated serious discrepancies between rocket measurements and the normally accepted conceptions of upper atmospheric conditions, the reports on the rocket operations themselves were quite significant.

In the beginning the upper atmosphere programme used captured German "V-2" rockets which were modified in a number of ways, principally to carry a gradually increasing payload. Later with the exhaustion of the supply of these war rockets, other new vehicles, the "Aerobee" and the "Viking" were designed and constructed. The results of all firings to January 1, 1952, are summarised as follows, and it is important to note that since that date there have been twenty-five "Aerobees" fired, all of which have reached expected performance.

	"V-2"	"Aerobee"	"Viking"
Total number of rockets fired	62	81	9
Average altitude reached (miles)	60	47	73
Maximum altitude reached (miles)	133	80	136
Number of normal flights ...	42	70	4
Average altitude of normal flights (miles)	82	54	121

It is important to note that the "Aerobee" high altitude sounding rocket is now almost 100 per cent reliable and that it could have a horizontal range of 100 miles.

In addition to the lesson learned from the mechanical aspects of rocket launchings the personnel records have a message for us. It is one which counters the usual criticism of the long-range rocket as a military weapon; its unreliability and its attrition of launching crews. For one group having an average employment of twenty-nine men over a period of sixty-nine months, only nine and a half man-days were lost due to accidents. This was typical of the groups concerned with the launching of some sixty-two modified "V-2" rockets.

While the "Viking" is still in the development stage it offers some instructive pointers towards future progress. Its motor gives only half the thrust of that of the "V-2," but it can carry similar payloads to even greater altitudes. Despite the fact that there have been no significant improvements in jet velocities, because structural temperature limitations in the combustion chamber cannot yet be overcome, a tremendous improvement has been made in the mass ratio. This relationship between take-off mass and dry weight when the propellants have been consumed has been increased by using an all-aluminium construction, by making the skin integral with the propellant tanks and by using the light structural materials close to their elastic limits. The "Viking" is thus able to carry 80 per cent of its take-off weight as propellants, compared with 67 per cent for the "V-2" and 55 per cent for the "Aerobee." A further improvement is likely to be made by the use of expendable tanks and by step construction. A two-step "Bumper-Wac" vehicle, launched on February 24, 1949, projected its second stage to an altitude of 242 miles.

Nevertheless, these rockets are expensive items of equipment. Moreover, they can be used only once. The "Viking," for example, costs £70,000 and the "Aerobee" £10,000. Instrumentations are extra.

There is a cheaper way of getting instruments to these high altitudes by using a system developed by Dr. J. A. van Allen, the head of the United States Rocket Panel. Currently available are a number of solid propellant military rockets which use high-energy propellants and which would have impressive all-burnt velocities if fired in a vacuum. When the performance of these rockets is computed for launchings at various heights in the atmosphere it is found the summit altitude ascends rapidly as launching takes place above the denser layers of air and the atmospheric resistance to the flight is minimised.

Launched at altitudes of 50,000ft the Deacon rocket can carry payloads of 30 lb to the 60 mile level. The solution proposed and tried by Dr. van Allen was to carry the rockets up to the launching position by means of large plastic "Skyhook" balloons. He labelled his vehicle a "rockoon." A number of highly successful flights were made during August and September, 1952, off the coast of Greenland, and a series of twenty-three firings is taking place at the present time. The rockets were instrumented for cosmic ray experiments near to the geomagnetic poles.

The small cost of these vehicles is noteworthy: the balloon takes £140, the rocket £280 plus its instrumentation. In this connection, too, it is interesting to note that even a ground-launched rocket need not be very expensive. The new French "Veronique," of which twenty-five have been fired, costs about £1600. This rocket uses nitric acid and gasoline as propellants, weighs 1100 kg and carries a 50 kg payload to a summit altitude of 60 miles. Firings have taken place from the Sahara and the instrumented nose cone is recoverable by parachute.

Results of all this high altitude research have, in some cases, been disconcerting. There has been no lack of ingenuity in the design of instruments but, nevertheless, the reports indicate a confusion in the precise interpretation of the measurements made by the rocket-borne apparatus. Always there appears to be an unknown factor which cannot be isolated and which upsets the conclusions. A good example of this is in the atmospheric separation experiments where an attempt was made to find out if diffusive separation of the atmosphere into its constituent gases takes place at high altitudes. Despite cleverly contrived methods for opening and sealing the sampling bottles at various altitudes while in flight, followed by the skill of the analysis in the laboratories, the results are still in doubt. Evidence of separation was found by the analysis and the theories appeared to be proved. Then similar evidence was detected in control bottles sent up from the ground and never exposed to the upper atmosphere.

Above an altitude of 60 miles the temperature measurements are similarly at variance with normally accepted theory. The definite acceptance of the rocket results would require a complete revision of all the previous work done in this connection. The model ionosphere based upon the escape of helium, the aurora and the formation and equilibrium of the ionised layers will have to be modified considerably.

But all the results have not been contradictory. A number of measurements have agreed with ground-based work, notably the determination of the ozone layers and the observations of winds in the upper atmosphere.

As for the instrumentations, the problem at the moment is to create a stable platform on which more sensitive instruments can be mounted to measure phenomena more accurately. A sun-follower photo-electric device, which rotated on two axes to point at the sun and give a stable reference system despite the aspect of the rocket, has found a limited success and needs further development. It is then hoped to fly a coronograph and thereby solve some of the problems associated with the solar atmosphere and its emissions which govern the formation of the ionised layers and affect radio communication and which are perhaps controlling factors in the aspects of the weather at ground level.

With the exception of some pioneer work done with plastic balloons by Bristol University, Britain's contribution has been mainly theoretical, or based on observations made from the ground. There is no doubt that some of our guided missiles could be modified to undertake upper atmosphere research and our missile guidance systems could be adapted for telemetering. Perhaps it is not too much to hope that with the partial lifting of the security blanket on British rockets, the Minister of Supply will permit non-military scientists to use some of the rocket vehicles for high altitude research. If he does so the lessons learned by the American workers must not be forgotten. They found that it is not possible to follow research programmes according to military schedules and to meet deadlines. The policy of "keeping the launching crews busy" is not a practical one which can be followed. The success or failure of upper atmosphere research depends upon a genuine correlation between the civilian scientist and the military people. If those who guide military thought appreciate the technical problems and realise that a large number of the decisions must rest with the engineers and the scientists and not with a scheduled military programme, a successfull high altitude programme can be followed.

WORKS COMMITTEES AND PRODUCTIVITY.—The Industrial Welfare Society is arranging a week-end course for workers' representatives on works committees to be held at Ashridge, Berkhamsted, from Friday to Monday, October 16th to 19th. It is the eighth course of its kind to be held during the past four years. At the opening session on Friday evening, October 16th, Mr. H. A. Watkinson, Parliamentary Secretary to the Ministry of Labour, is to speak on "What Productivity Means to Britain."

PURCHASING OFFICERS ASSOCIATION.—The Purchasing Officers Association is to hold its national conference and "minibition" at Brighton, from September 24th to 27th. At the official opening of the conference, on September 25th, an address will be given by Mr. L. W. Joynson-Hicks, Parliamentary Secretary to the Ministry of Fuel and Power. It will be followed by a discussion on "Coal in the National Economy." At succeeding sessions of the conference the discussions will be concerned with production control, packaging and materials handling, and with various aspects of purchasing. On the morning of Saturday, September 26th, Mr. J. B. Hynd, M.P., will speak on "Britain and the Schuman Plan."

The Water Supply Problem in Texas

(By Our American Correspondent)

THE severe drought which has been prevailing in Texas has once more drawn attention to the serious water supply problem faced by that state, and a comprehensive report on the problem and on its possible solutions has just been published by the U.S. Bureau of Reclamation. The borders of Texas embrace water resources which, if regulated and distributed to points of potential use, could satisfy needs much larger than those now foreseeable. The waters are unevenly distributed, however, and cannot economically be made available to all points of need. The development of several sections of the state has now reached the limit permitted by available water resources, and other areas are rapidly approaching both their industrial and irrigated agricultural limit of development since water supplies cannot be economically increased under foreseeable conditions. As shown in the accompanying map, Texas may be divided into four water supply problem areas: High Plains, Pecos Valley-Trans Pecos, Central and Gulf Coast. The Central area, in turn, on the basis of water supply problems, may be subdivided into the Edwards Plateau region, the Red Bed region, and the area generally east and south of the Balcones escarpment.

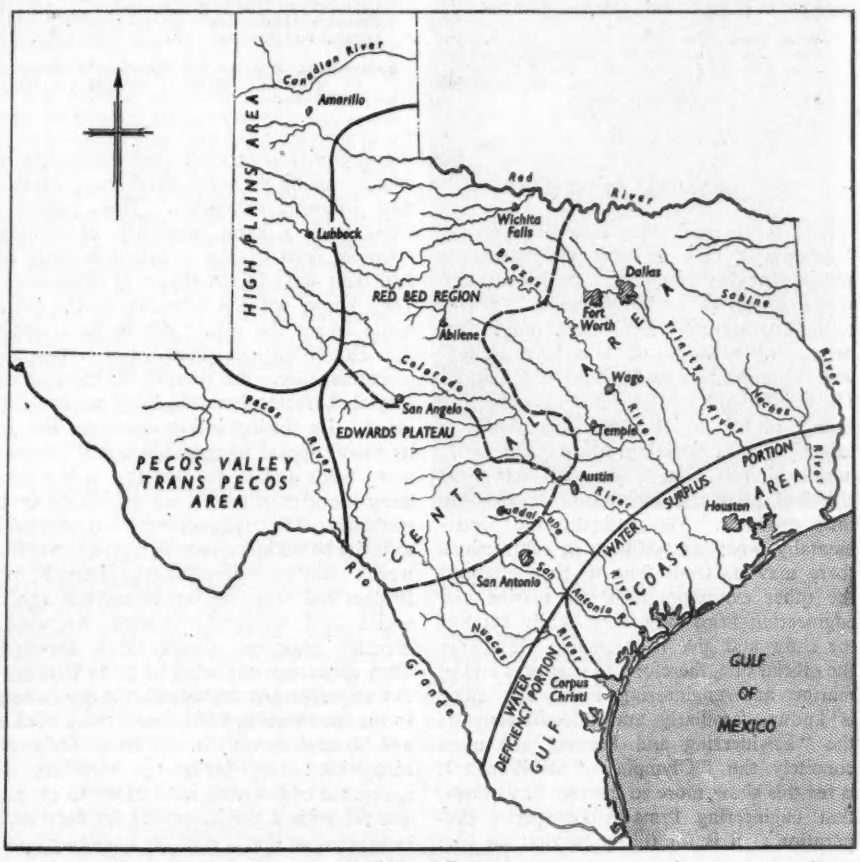
The water resources of the High Plains area consist of a vast supply of underground waters and the portion of the flows of the Canadian River available to Texas under the terms of the inter-state agreement governing that stream. There are other minor surface flows in the area, but they are insignificant in the light of potential demands. The underground water supply is at present the basis of the entire irrigated agricultural and industrial economy of the area. Withdrawals for the irrigation of more than 2,000,000 acres and for the municipalities and industries are many times greater than the rate of recharge. As a result, the water table has steadily declined in the heavily pumped areas. This ultimately will make irrigated agriculture in most of the area either impossible or unprofitable. The problem facing the area is one of augmenting the dwindling ground-water supplies, as the extensive oil and gas resources of the area ensure its continued industrial expansion provided that reasonably priced water supplies can be obtained.

The water problems of the Pecos Valley-Trans Pecos area are those of shortage of water supply and lack of opportunity for development of additional supplies. The arid nature of the area has resulted in a full development of the available surface and ground waters to satisfy municipal needs and existing irrigation developments, and there are no opportunities in the foreseeable future for an economic importation of water from areas having surplus waters. The problem thus reduces to a more effective use of existing water supplies, a possible reduction of non-beneficial consumptive uses, and perhaps a reapportionment of available water supplies between inferior and superior uses.

Within the Central area, the Red Bed region has serious municipal and industrial water supply problems of limited magnitude. This portion of Texas has long suffered from water supply shortages. The development of extensive oil and gas reserves in the region has produced substantial population growth, some industrialisation, and an increased need for additional water supplies. Also, years of low run-off have accentuated the water problems of towns not affected by the industrial developments. The shortage of usable ground water, excessive mineralisation of much of the surface flows, and the limited and erratic run-off of streams in the region make a development of adequate water supplies costly. Estimates of future municipal and industrial water requirements and available water resources have indicated that these requirements can best be satisfied by multi-city water supply schemes in which two or more cities join forces to develop a common source of supply. The physical characteristics of the Edwards Plateau region are such that water demands of large magnitude have not developed and are not likely to occur. Its ground water supplies are generally sufficient to satisfy the water requirements of its economy and of the relatively small municipalities. The water supply problems of the portion of the Central area generally east and south of the Balcones escarpment, though numerous, are generally not as pressing as those of the Red Bed region, nor are they of the magnitude of the problems of the Gulf Coast area. It is generally a water surplus region in which locally available water resources are more than adequate to supply all foreseeable municipal and industrial water demands. Flood control has been a major problem, and a number of reservoirs either have been developed, authorised for construction, or proposed for planning.

The Gulf Coast area is considered to have the largest water supply problem in Texas. If proper use is made of available water resources the area will provide the largest foreseeable economic gains to the state. This region, which comprises only 11 per cent of the area of Texas, contains 28 per cent of its population and even now produces 30 per cent of its total income. Most of the large water-using industries are concentrated in the area, including 85 per cent of the petroleum refining industries, 79 per cent of the petro-chemical industries, 80 per cent of the synthetic rubber industry, all the sulphur-producing industry, and most of the works producing chlorine, magnesium, tin and zinc. The industrial and agricultural growth represented by these developments has largely come into being since 1940. It is based on the vast natural resources existent in and near the area as well as the favourable location with respect to water transportation. The present water use in the area is about 3,900,000 acre-feet annually, with 3,100,000 acre-feet coming from surface water sources and 800,000 acre-feet from ground water. About 3,300,000 acre-feet are used for irrigation and 600,000 acre-feet are used for municipal and industrial purposes. In some areas, the rate of withdrawal has exceeded the rate of recharge, and substantial and continuing declines of ground water levels have occurred. Surface water use, however, constitutes not more than a small percentage of the flows now discharged into the Gulf of Mexico.

An integrated plan has been developed by the Bureau of Reclamation for the Gulf Coast area of Texas to provide for a regulatory storage aqueduct for future water requirements and a common distribution system to deliver water to points of need. The plan contemplates an integrated system of reservoirs and distribution works capable of satisfying the estimated water requirements of the region. Because much of the water supply of the area is concentrated in the eastern section, westward transport of water will be necessary to meet the overall requirements. This is a relatively simple task since no formidable physical barriers are present to impede such transport, but it will require pumping lifts at intermediate points. Compared with the engineering problems that faced Southern California in the transfer of Colorado River water to the Los Angeles area, the task is relatively simple. The plan is one of great magnitude, with a total capital cost in excess of 1000 million dollars. It is susceptible to development stage by stage as the estimated water requirements occur and need not be considered for immediate construction in its entirety. It would ultimately provide a minimum of about 12,000,000 acre-feet of reservoir space on streams in the Gulf Basin, for the primary purpose of providing reliable water supplies for industry, municipalities, and agriculture. Specific dam sites on the various rivers have not yet been chosen, and the quantities of reservoir capacity indicated for the various streams may be altered to meet individual requirements. It is likely that large amounts of the storage capacity required would be provided at sites where reservoirs are now proposed primarily for flood control purposes.



Map of Texas

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ENGINEERING, MARINE AND WELDING EXHIBITION AT OLYMPIA — SIXTEEN-PAGE ILLUSTRATED SUPPLEMENT

THE OLYMPIA EXHIBITION

How the years flash by! It seems merely "yesterday" that we were visiting stands and exchanging greetings with friends and acquaintances at the last Olympia "Engineering and Marine" Exhibition. Yet in fact two years have passed and "yesterday" was the opening day for the 1953 edition. The Exhibition has more than once suffered a change of its official title. This year it is called "The Engineering, Marine and Welding Exhibition," and for the first time chemical plant manufacturers are showing their products. Yet, basically and fundamentally, whatever additions or subtractions there may be from time to time amongst the other exhibitors it is the marine and engineering firms who consistently support the show and give it character. Whatever the official title, therefore, to engineers and to marine and engineering firms, the affair is known familiarly and affectionately as the "Engineering and Marine," or more concisely the "Olympia" Exhibition. It is for this show, more so than for any others, that engineering firms make special preparation; it is for this show that the first presentation of some new product or development is reserved by regular exhibitors; and it is upon this show, rather than upon others, that more newly founded engineering firms depend to reveal the virtues of their products to potential customers; and also to the, perhaps critical, gaze of engineers in general!

The "Olympia" Exhibition—we use that short title in the confidence that however much confusion may be created amongst laymen aware how many and varied are the exhibitions held in those halls no engineer will misunderstand it—is markedly different from the majority of others. Over the years it has acquired a particular character, all its own. Firms may come and firms may go. But there remains a very large proportion of exhibitors who are wedded to the regular showing of their products and who regularly engage exactly the same stand space, exhibition following exhibition. Thus engineers who make a habit biennially of visiting Olympia need to buy a catalogue only to find their ways to the stands of newcomers. They know, without reference to the catalogue where the others are to be found! The Exhibition has, therefore, a certain air of permanence. But there is far more to its special character than this air of permanence alone. Its distinguishing character lies in its broad appeal to engineers specialising in many fields and in the fact that it is something more than merely an exhibition or a trade fair. The organisers certainly take care to invite potential customers from all over the world. But long since, its organisers, F. W. Bridges and Sons, set out to make it also a social and technical occasion to which bienally engineers should look forward. They encourage engineers to go to Olympia, not as prospective customers, not even solely to see the exhibits, but to meet there friends and acquaintances for informal technical discussion; they invite the members of numerous engineering institutions to attend, and set aside a particular day for each such institution so that a member attending upon that day can feel sure of meeting acquaintances. This strong social aspect of the Exhibition is further stressed by the fact that it opens just as the holiday season is coming to its end and engineers, refreshed, are beginning to look forward to meeting friends and acquaintances again and renewing technical discussion. Where else can technicalities be better discussed informally than at the Exhibition, where the product concerned can be examined "in the round" and the different ways of overcoming technical problems adopted by individual manufacturers can be observed! It would be an exaggeration to suggest that the main purpose of the Exhibition has become technical and social. The seeking of orders and signing of contracts is still important. But any manufacturer who sought to evaluate participation by calculating only in terms of inquiries placed and firm orders taken would be making a mistake. He would be failing to take account of the value of the interchange of technical information and criticism that takes place at the show. He would be discounting the importance of renewing acquaintanceships; and undervaluing, even, the instruction of those so youthful that it must be very many years before they can be thought about as potential customers or valued friends!

For our part we endeavour in a Supplement to this issue and in accounts that will appear in subsequent issues to give some impression of the Exhibition to those unfortunate many who will have no opportunity to visit Olympia. But since space is limited we have necessarily to be selective, choosing in particular to describe products that are wholly new or which have recently been subjected to considerable development. Repeatedly in preparing that account during the weeks before an "Olympia" exhibition has opened we have felt slightly disappointed. So little that is really new seems to be exhibited each time. Yet, as repeatedly, once the doors of the Exhibition have opened all disappointment has evaporated. For, after all, two years is not a long period in the advancement of engineering. It is surprising not that there is so little development in so short a span but that there is so much! The opening of yet another Olympia "Engineering and Marine" Exhibition is a great engineering occasion.

THROUGH A GLASS DARKLY

One who has spent all his life in a mountain valley knows every detail of his present dwelling place but little or nothing of the nearer valleys upon either hand. Yet if he can but climb upon some eminence he may perceive, all detail being reduced to insignificance, the immensity of the mountain range of which his valley forms a part. So it is when we look ahead in time. The present we know. The nearer future is obscure. But if we lift up our eyes we can observe clearly, or think we can so observe, the heights that make up the ranges of future but very distant history. Like Sir Charles Darwin, in his book, "The Next Million Years," we may, by casting aside all detail, gain enough confidence to make predictions about the more distant future of mankind, predictions more precise than any we should dare express about events closer to our own time. In his presidential address to Section G of the British Association which we reprint on another page of this issue, Lord Dudley Gordon, like Sir Charles, peered into the future. But as he set his sights lower, surveying merely two thousand, instead of a million years ahead, it would be idle to expect as much precision from him as Sir Charles proved able to attain. In a total period of a million years the effects of the rise and decline of civilisations, the breaking up of alliances, the fusions of mixed peoples, become irrelevant to the main theme. But within so short an interval as a mere 2000 years their effects remain far-reaching and important. Yet within the limited field of engineering with which Lord Dudley dealt their consequences are still unlikely to be

great. Despite wars, political and national rivalries, economic disasters and the strife of demagogues, the work of engineers goes forward with but little interruption. War or misplaced nationalism may hold back the development of a backward country ten, twenty or thirty years. The courage and foresight of great men may hurry forward advances by a like amount. But within a span of 2000 years a few decades is neither here nor there. Before 2000 years have passed it can safely be assumed that engineers will have developed enormously the world's resources for the benefit of mankind.

But, also within 2000 years, as Lord Dudley Gordon emphasised, engineers may find themselves running short of the resources upon which they rely to improve man's estate. For to whatever material the engineer turns for structural purposes or for fuel he draws upon limited stocks laid up in the crust of the earth. That remark may, it is true, be inapplicable to vegetable products. But as, within 2000 years, the earth's population may have multiplied a million times it is unlikely that much ground could be spared for the growth of crops other than those of food ! Thus, much of Lord Dudley's address was devoted to an examination of the sources from which engineers might draw power and materials when present sources dry up. There a fog of uncertainty shrouds the nearer future more effectively than the more distant. For it is easier to perceive that reserves of certain materials, and particularly oil and certain ores of non-ferrous metals, will soon approach exhaustion than to pinpoint exactly how soon they will do so. But in the longer run that point is unimportant. Sooner or later engineers will have to seek sources of material, as under the sea or in the sea, or deep within the earth's crust in places not yet fully explored or even contemplated for exploration ; and, seeing that stocks of uranium must also be as limited as those of more conventional fuels, seek either new ways of generating power from the sun or to develop nuclear power from hydrogen, of which almost inexhaustible supplies exist. Great and intriguing problems face the engineers of future ages as they seek to raise the productivity of the earth. Yet about one of Lord Dudley's statements doubt may still be expressed. He thinks it " seems certain that in future years the progress of engineering science will be more rapid than it was in the nineteenth century. . . ." But does not scientific progress suffer from the law of diminishing returns ? Already engineering advances are less easy to gain than in the past and greater research effort must be put into their winning. Within 2000 years the returns may no longer justify the effort ! If so engineering progress will come to an end, design become standardised and static and civilisation will revert, as it has so often reverted after startling advances in the past, to an unchanging rhythm such as ancient Egypt experienced for well over 1000 years.

In any attempt to look into the future many imponderables are present. Sir Charles Darwin endeavoured to evade them by studying the future on so vast a scale that the rise and fall of great new cultures and civilisations, the fits and starts by which man progresses, were smoothed out by the scale. Similarly, Lord Dudley Gordon has tried to avoid them by restricting his field to engineering and his time to within a period in which the world's population, though enormously expanded, might still not yet be beyond the power of engineers to supply from the earth's resources. Both, however, steered clear of one possible change in man's situation that could have profound effects upon their conclusions and reflections. Can anyone who knows anything of rocket developments seriously doubt that long before the year 3953 man will have made an attempt to explore the Solar system ? It seems to us a certainty because, even if the appeal to adventure and the challenge to the technical skill of engineers should prove insufficient as incentives, the pressure of increasing population *vis-à-vis* a growing shortage of food and of raw materials must sooner or later make the attempt inevitable. If the attempt fails, if man can neither spread over the Solar system nor draw wealth from it—a by no means impossible outcome—then the rather gloomy prophecies of Sir Charles and the more exhilarating reflections about the future of engineering expressed by Lord Dudley Gordon may come true. Certainly Lord Dudley's conclusion that the next few generations will need to start investigating new sources of raw materials and power if standards of life are not to fall is sound. But what if the attempt succeeds ? The conclusions both of Sir Charles and Lord Dudley are based upon the confinement of man to the surface of the earth. Once that prop is removed how dare anyone predict anything about man's future ?

Obituary

JAMES WILLIAMSON, C.B.E.

ENGINEERS and particularly those engaged in the profession of civil engineering will have learned with regret of the death of Mr. James Williamson, which occurred on August 18th, in his seventy-third year. Mr. Williamson, who was the senior member of the firm of James Williamson and Partners, which he formed in 1947 with Mr. E. J. K. Chapman and Mr. W. Young, was well-known for his work on hydro-electric and water power schemes. His work in this field extended over many years, going back to 1923, when he was concerned with the Humber Arm water power scheme and paper mill in Newfoundland and also the Galloway water power scheme. In recent years he was closely associated with hydro-electric development in Scotland and in 1941 was appointed by the Secretary of State for Scotland a member of the Cooper Committee to investigate such developments.

James Williamson was born on April 5, 1881, at Westfield Farm, Holytown, and received his early education at the nearby Uddingston Grammar School and afterwards proceeded to the Royal Technical College and Glasgow University to follow a course of technical education. During the four years from 1899 to 1903 he served an apprenticeship with the Engineer to the Middle Ward of the County of Lanark and gained experience in the design of drainage, sewage purification works, highways and bridges. Subsequently he joined the firm of Formans and McCall as an assistant engineer, becoming chief assistant in 1907, and during those years was largely engaged in railway construction work. This included the building of the Lanarkshire and Ayrshire extension lines of the Caledonian Railway, surveys of that railway and of the Paisley and Barrhead railway, and work on gravity marshalling sidings on the Clydebank Dock Branch Railway.

In the immediately succeeding years Mr. Williamson was in charge of a variety of work ranging from drainage systems to dock and harbour extensions and including a considerable amount of structural design of diverse character, such as the steelwork for large buildings, factory extensions. He did some estate work and temporarily returned to railway activity—when he prepared plans for the Dingwall and Cromarty Light Railway—before spending a year with the Cleveland Bridge and Engineering Company, gaining additional experience in structural design and manufacture. In 1913 he was again with Formans and McCall, being mainly engaged on structural work for

James Williamson

the Aberdeen passenger station, a biscuit factory and some water supply projects. The beginning of the first world war found Mr. Williamson in charge of surveys for a cordite factory at Ardler and for an 80-mile broad and narrow-gauge railway system for H.M. Explosives Factory at Gretna, Scotland, and also on the preparation of plans for the factory. Later he was transferred to S. Pearson and Son, Ltd., the construction managers for the Gretna factory, and became chief of the civil engineering department responsible for the acids and guncotton section. For a few months in 1917 Mr. Williamson occupied a similar position with the Ministry of Munitions at the Henbury explosives factory near Bristol and then joined the Royal Engineers with the rank of lieutenant. In this capacity he was engaged on design work connected with the channel trainferries and reinforced structures for the Richborough port and certain aerodromes, and was then seconded for work on various reinforced concrete barges and tugs, which were built at Shoreham Shipyard.

For two years, 1920–22, Mr. Williamson was in private practice in Westminster and then became chief engineer to Sir Alexander Gibb and Partners and continued with them until 1936. Many major works were carried out under his charge, including the Barking power station, Ipswich harbour extensions, the Maentwrog hydro-electric scheme of 24MW capacity, the 102MW Galloway

water power scheme and the preparation of designs for the Humber Arm and Gander Valley water power and paper schemes in Newfoundland, and the Uhl River water power scheme, Mandi State, India. In addition to the above many important miscellaneous works were dealt with, ranging from a colliery ropeway, a shipyard fitting-out quay, flood prevention measures and harbour schemes to train ferry bridges. Following a year in which Mr. Williamson reverted to private practice as a civil engineer, he accepted an invitation, in 1938, to join Sir William Arrol and Co., Ltd., as a director and chief engineer, and he continued to occupy this position for the next six years. During this period he supervised the design and construction of bridges, factory buildings, the establishment and equipping of shipyards, and the assembling and launching of tank landing craft at Alloa. Items of special interest were the construction of a cylindrical steel chamber for testing model aeroplanes under high or low pressure at speeds up to 600 m.p.h. and the rapid building of an aeroplane factory near Chester.

As already mentioned, Mr. Williamson served, in 1941, on the Cooper Committee, which reported on hydro-electric development in Scotland and, following the constitution of the North of Scotland Hydro-Electric Board in 1943, he was appointed a member of the panel of consulting engineers to the Board. Since then he had been employed in planning hydro-electric developments in the Board's area. In 1943 he collaborated with Freeman Fox and Partners in preparation of a report on further hydro-electric development in North Wales, covering schemes having a potential of 300,000kW. In the following year, Mr. Williamson began practice as a consulting civil engineer in Glasgow, and three years later, in 1947, as already noted, the firm of James Williamson and Partners was constituted. Since 1944 he had supervised much work for the Hydro-Electric Board, including the civil engineering works for the 130,000kW Loch Sloy project, the Glen Lussa scheme in Kintyre, the Lawers scheme, and the 59,000kW Lyon-Lochay scheme, and his firm has also been responsible for civil engineering work for a number of new steam stations.

Mr. Williamson, who was made a C.B.E. for his work, was a member of the Institution of Civil Engineers. He read a number of papers before that institution and elsewhere and was also the author of a number of technical books.

W. S. HUDSON

We regret to record the death of Mr. Walter Skelton Hudson, of Low Hall, Kirkby Overblow, which occurred after a sudden illness on Wednesday, August 26th. Mr. Hudson, who was in his seventy-seventh year, was the last of the four sons of the original Robert Hudson, whose business was founded in 1864, upon the realisation of the future of narrow gauge railways in mining work, about the time of the development of the De Beers diamond mines. Mr. Walter Hudson was chairman of Robert Hudson, Ltd., whose main works are on the original site at Gildersome, and of a subsidiary company with its works bearing that name at Benoni, near Johannesburg, Durban. The Hudson brothers built up, through difficult times, the development of light railways for all industrial purposes and succeeded in establishing a world-wide organisation, first as a private partnership, then as a limited company and, finally, in 1948, as a public company.

Walter Hudson took an active part in this business up to the time of his death and travelled widely in connection with its activities. He followed the Bramham Moor Hunt for a long period and was a Wetherby magistrate.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

DESIGNING BY PHOTOELASTICITY

Sir,—In the review of my book, *Designing by Photoelasticity*, which appeared in the issue of May 22nd, some errors of fact are stated. The frozen stress method in photoelasticity is stated to possess an "inherent limitation to problems which are axially symmetric, or otherwise have known principal axes." I would point out that two methods of solving the directions and magnitudes of boundary stresses in an asymmetric part are given in the book. My "dismissal" of Hetenyi's result for the maximum stress in a bolt has since been substantiated by Brown and Hickson in a paper to the Institution of Mechanical Engineers. The statement that "many workers in this field will feel that much more experimental confirmation is required before Neuber's figures can be given unquestioned credence" is the sort of statement that could be applied with equal veracity to the whole field of stress analysis results. With reference to the logic of an empirical formula, the reviewer has misrepresented a suggestion prefixed in the book by "may give" with the positive words "is therefore," thus distorting the meaning.

Finally, I am grateful to the reviewer for pointing out an error in my analysis of a limiting case of Sonntag's formula.

R. B. Heywood

Camberley, Surrey,
August 21st.

THE HARROW ACCIDENT

Sir,—I think a grave injustice was done to driver Jones in paragraph 80, Official Report, in overlooking the fact that driver Jones and his fireman, Turnock were both exceptional, intelligent and experienced enginemen, would work in unison on the alert for signals which ever side they were on, a double check for safety in poor visibility. Both knew the importance of the Harrow No. 9 up fast distant signal as a check point, and danger of a local train being switched ahead on the up fast line would increase their vigilance. It was impossible for the distant signal to be missed with two experienced enginemen on the footplate. Even if driver Jones missed the distant he could not under-estimate the distance from Hatch End because the Headstone Lane overbridge was 23 yards beyond the distant ; again, his fireman would have warned him they were passing Headstone Lane Station on his side, 1400 yards from Harrow outer home signal, ample distance for brake application. In para. 53, O.R., all engine controls for stopping, a 60 seconds preparation, were found completed in the examination of engine after collision. These facts should clear the signal query. The most important factor was the fatal delay in brake application. In over forty years' skilled railway experience I have known a few rare cases of drivers being suddenly engulfed in a dense fog of choking condensing steam from boiler through a snapped-off water gauge bottom drain cock, when in use. Some drain cocks are hard to shut, owing to boiler sediment passing through the drain cock ; the handle has to be shut with a blow. These phosphor bronze cocks can be over stressed beyond the elastic limits of the metal when fitted. A fine fracture starts at the root of the threaded end that screws into the middle column. The stretched grains of the metal, under working conditions, will keep snapping, causing a creeping fracture ; the cock will suddenly snap off flush if extra force is used. Photo. No. 3, O.R., of the boiler front inside cab, a snapped-off drain cock with handle half shut, facing fireman's side, is shown on driver's side. If this cock snapped off accidentally by fireman when driver Jones was preparing to stop, the temporary delay to driver Jones would account for the brake application at the last few seconds. Para. 5, O.R., "drain cock had been torn off in collision." The tensile stress required for a sound phosphor bronze cock screw end of 1¼in diameter would strip threads and inside threads from middle column, which, being reduced near flange, would bend down or snap off. Appendix D.O.R., "drain cock snapped off immediately below the cock body, i.e. middle column in collision." The heavy blow required to snap off a phosphor bronze drain cock screw end 1¼in diameter would severely damage middle column. There was no damage to middle column or gauge glass. A metallurgist report on the snapped-off cock should have been included in official report.

T. Lawrence

Harwich, Essex, August 27th.

SCIENCE AND PRODUCTIVITY

Sir,—In your issue of August 21st, Mr. Scammell calls attention to the difficulty which small and medium-size firms frequently find in introducing new techniques and processes. It is not unfairly suggested that the information made available to industry to-day from one source or another is more readily assimilated and applied in the production shop by the large firm.

I write to suggest, however, that in this discussion Mr. Scammell does, perhaps inadvertently, less than justice to the services which most of the D.S.I.R.-sponsored research associations offer to the smaller firm. He truly says that many such firms need demonstration by an expert of the way in which a new technique can be used in a particular factory where limitations of plant, space, &c., offer difficulties. Most of the industrial research associations do, in fact, offer just this advisory service to members in helping them apply new knowledge and use new techniques. Clearly, the service offered in this way falls in all too many cases short of what either the research association or the industry would wish, and there are some matters, particularly those concerning management and administration on which research associations generally are not in a good position to advise.

I write, however, to point out that a great deal of what Mr. Scammell so rightly suggests is needed to-day can be provided and is being offered by the research associations, and that the development and wider use of these facilities is the simplest and most obvious way of making immediate progress. The fact that the research associations are not in all cases able to deal with all the matters to which Mr. Scammell draws attention should not be allowed to obscure the immediate and useful assistance that they can give.

G. L. Bailey
Director

British Non-Ferrous Metals Research Association,
London, August 27th.

Books Received

Introductory Electrical Engineering, Circuits and Machines. By Clodius H. Willis and Henry M. Chandler, jun. London : Macmillan and Co., Ltd., St. Martin's Street, W.C.2. Price 52s. 6d.

Generation, Transmission and Utilisation of Electrical Power. Third edition. By A. T. Starr. London : Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 20s.

Introductory Engineering Materials. By Irving H. Cowdrey and Edward L. Bartholomew, jun. London : McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, E.C.4. Price 48s.

The S.B.A.C. Flying Display and Static Exhibition

No. 1

THE flying display and static exhibition organised each year by the Society of British Aircraft Constructors will be held at Farnborough next week commencing on Monday, September 7th. The general public will be admitted from Friday onwards and the exhibition concludes on Sunday, September 13th.

All the super-priority production bomber and fighter aircraft are expected to fly at the display and may probably be joined by other research or prototype aircraft not hitherto announced. For the first time civil aircraft are to have a day to themselves, Thursday's display being entirely devoted to the demonstration of civil jet and piston-engined airliners and helicopters. Altogether, over fifty aircraft will participate in the event, over two-thirds of them being powered by gas turbines.

In all, over 200 companies will be participating in the static exhibition and the display of aero-engines will be one of the dominating features.

Although several other nations, notably America, are now extensively engaged in the development of the gas turbine, this country still retains a convincing lead. Several distinct factors in the evolution of this power unit, particularly of the turbo-jet units which have emerged, distinguish its present development. Foremost is the rapid increase in total thrust which has been achieved either by uprating the earlier engines up to the 10,000 lb thrust category, or for thrusts in the 10,000 lb to 15,000 lb thrust category, compounded engines have been run. In achieving these thrusts there has been a general decrease in fuel consumption rates. Development has been entirely directed upon axial-flow engines with increased compression ratios generally with annular combustion chambers superseding the use of separate combustion chambers and largely as a consequence of these factors diameters have been restrained, with the result that thrusts per unit frontal area show a significant increase. At the same time, the specific weight has shown a distinct tendency to drop. These trends are not naturally confined to British engines, but in all these respects here, they are more distinctly evident.

Great Britain now has at least two turbo-jet engines which have been produced to develop thrusts in the 10,000 lb dry static thrust class from earlier more modest ratings. One of these engines is the "Avon," of which the prototype developed 6000 lb s.t., and the other is the "Sapphire," a later engine which began with a 7500 lb s.t. rating and is in mass production, type tested at 8300 lb static thrust and a mark is under development in about the 10,000 lb s.t. class. In the engines which have started their development life in the 10,000 lb static thrust class there are the Bristol "Olympus," a "double-spool" turbo-jet engine which is in production, and the Rolls-Royce "Conway," a by-pass or ducted fan turbo-jet engine which is still at the test stage and is reported to give over 11,000 lb static thrust. Dwarfing all other engines reported anywhere to have run is the recently announced "Gyron" turbo-jet, an engine regarded in the United States as being in the 15,000 lb static class. There are a number of other engines in the world now being developed in the 10,000 lb class, but only one is in production, that being the American Allison "J 71" turbo-jet engine which is fitted to two production bomber aircraft stated to be capable of 700 m.p.h., the Douglas "B 66" and the "RB 66," and the Republic "XF 103," a prototype delta wing fighter with a top speed expected to be 800 m.p.h. Although the frontal area of this engine is reported as only 37in, Rolls-Royce, Ltd., maintains that its latest "Avon" engine, which is comparable in thrust, the "RA 14," develops the greatest thrust yet achieved per square foot of frontal area, and at the same time has the lowest specific weight reported of any turbo-jet engine in any category with the exception of the British "Adder" short-life engine.

Gas Turbines Displayed

The "Avon" axial-flow gas turbine, perhaps one of the most celebrated of all gas turbines thus far in their development, will once again be the centre of attraction on the stand of Rolls-Royce, Ltd., Derby. This engine was born when suspicion of the gas turbine was far from quelled and at a time when the relative merits of axial and centrifugal compression were still hotly contested. Yet since its first flight in 1948 it for long bore alone the burden of powering most of this country's bomber and fighter prototypes, a task which it later shared with the "Sapphire," and more recently with the "Olympus" turbo-jet engines. The "Avon" prototype was first rated at 6000 lb static thrust and it then weighed 2400 lb. A later production version, known as the "RA.7," develops 7500 lb (dry) static thrust and weighs 2550 lb. The after-burner equipment developed for this engine (which is then classified as the "RA.7 R") raises the thrust to 9500 lb and its weight is 2470 lb. This engine was commented on in our columns on March 20, 1953, on the occasion of an announcement stating that it had passed a 150-hour type test at a rating of 9500 lb. An intermediate mark of engine is the "RA 3" of 6500 lb thrust, which has a weight of 2275 lb. It is the commercial version of this engine which is now fitted to the "Comet II" series. The latest version of this engine, the "RA 14" (Fig. 2), which is to be exhibited, was reported in our columns on August 14, 1953 as being in mass production, and it has been type tested at 9500 lb thrust, the commercial mark, "RA 16," being rated at 9000 lb s.t. This engine has a diameter of 41·5in with the astonishingly low weight of 2860 lb, its specific weight being 0·301 lb weight per pound thrust, which compares with 4100 lb weight of the American "J 71," 10,000 lb

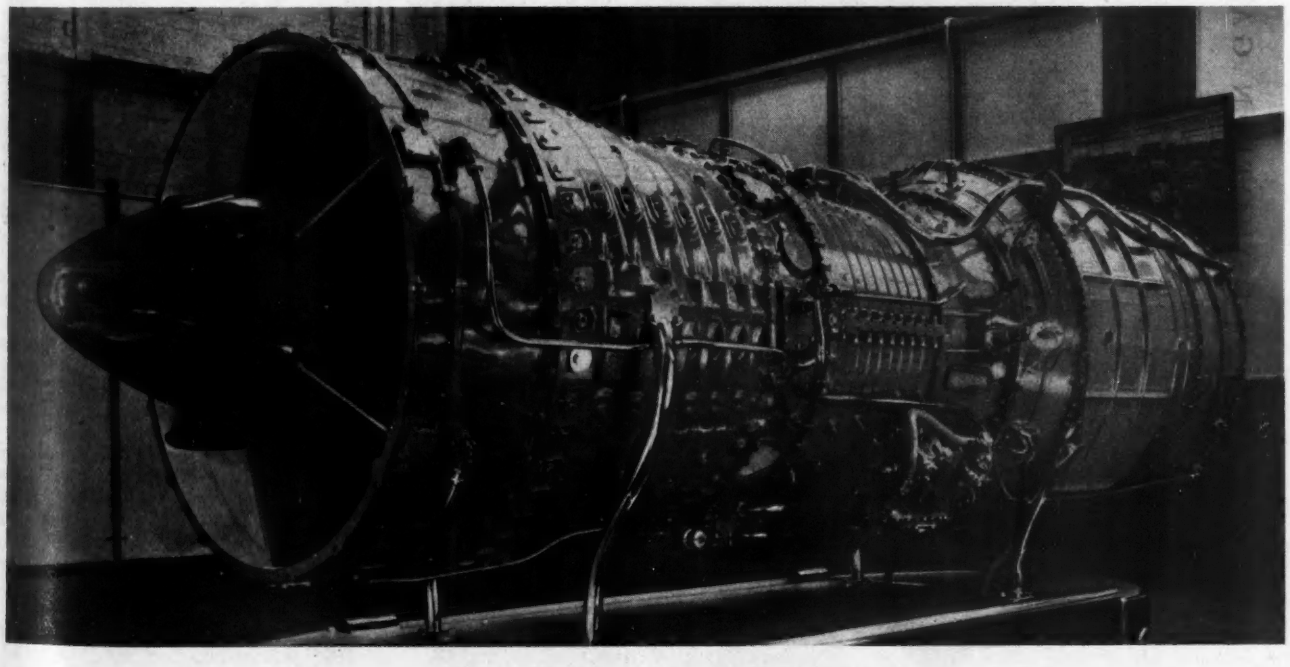


Fig. 1—The Bristol "Olympus" Turbo-Jet Engine

PRODUCTION GAS TURBINES AT THE S.B.A.C. EXHIBITION

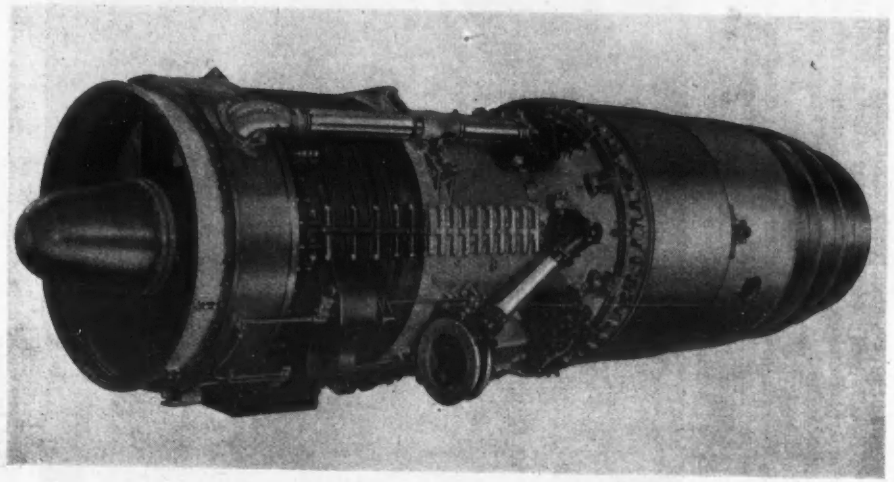


Fig. 2—The Rolls-Royce "Avon RA 14" Turbo-Jet Engine

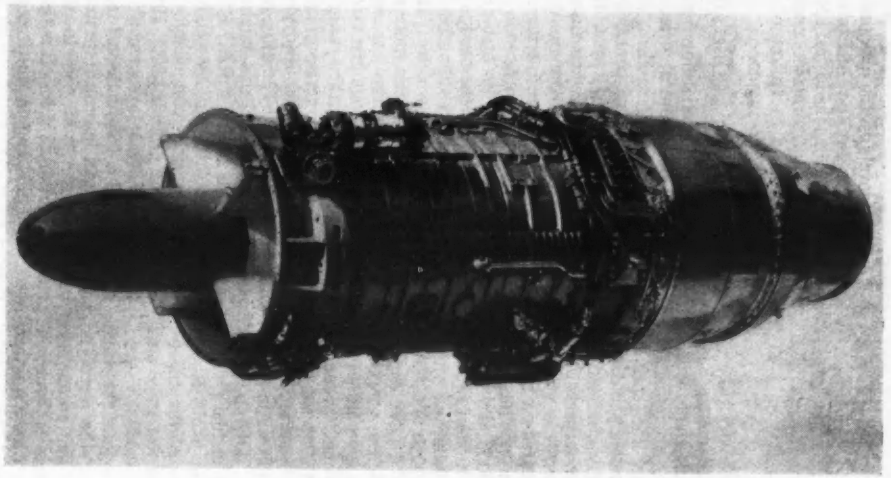


Fig. 3—Armstrong Siddeley "Sapphire" Turbo-Jet Engine

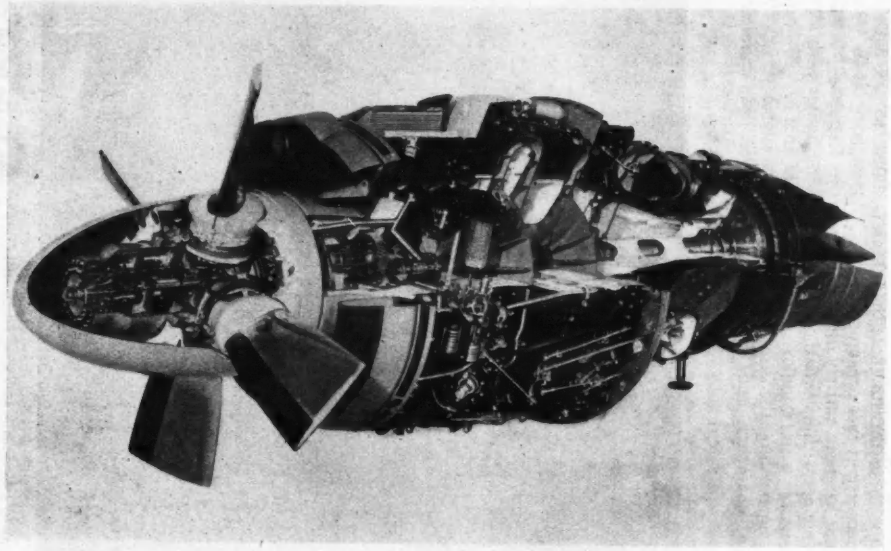


Fig. 4—The Rolls-Royce "Dart" Turbo-Propeller Engine

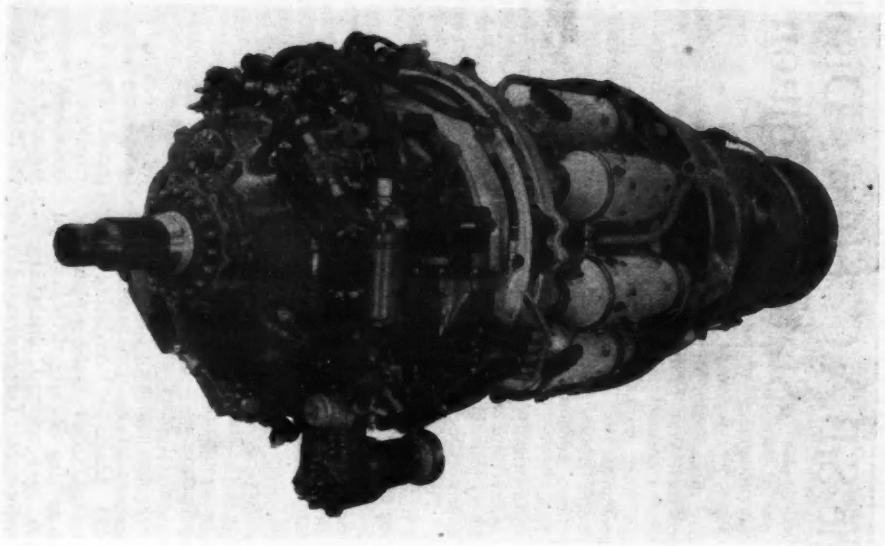


Fig. 5—The Bristol "Proteus 705" Turbo-Propeller Engine

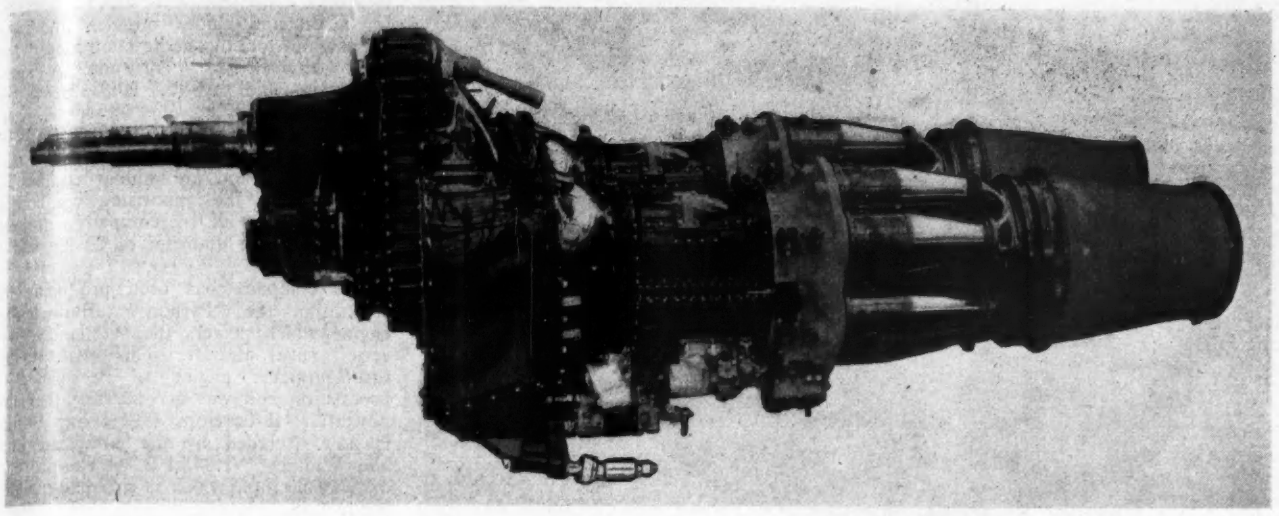


Fig. 6—The Armstrong Siddeley "Double Mamba" Turbo-Propeller Engine

turbo-jet engine. The specific fuel consumption of 0·84 lb per pound thrust per hour also compares with 0·9 lb of that engine. Our illustration suggests that some form of annular combustion chamber has superseded the external cans of former marks.

Complete marks of the "Avon" engine are now in mass production at five different factories in this country. Abroad the "RA 3" and "RA 7" marks are to be produced by the Commonwealth Aircraft Corporation Pty., Ltd., of Australia, the Svenska Flygmotor A.B. in Sweden is converting from de Havilland "Ghost" production to that of the "RA 7" engine, and manufacture of this engine is now being arranged at the Fabrique Nationale d'Armes de Guerre in Belgium.

Details of the "RA 7" engine show that it has a twelve-stage axial compressor with two-position linked and pneumatically operated inlet swirl vanes. There are eight straight-through combustion chambers and a two-stage turbine, with air-cooled rotor discs, the take-off speed being 7800 r.p.m. The overall diameter is 42·4in and the length over the starter motor cone is 119in.

Another of the production gas turbines which Rolls-Royce will be exhibiting is a sectioned model of the "Dart" propeller turbine (Fig. 4), the power unit of the Vickers "Viscount" air liner. This engine has two single-sided centrifugal impellers giving a compression ratio of 5·5 : 1 and a two-stage "fixed" turbine. The maximum gas temperature is given as being 850 deg. Cent. at the turbine with a speed of 14,500 r.p.m., the air mass flow being 20 lb per second. The "RDa 3" engine develops 1515 e.s.h.p., which includes 365 lb jet thrust, and its maximum fuel consumption is 0·77 lb per equivalent shaft horsepower per hour. The maximum continuous power at 300 m.p.h. forward speed is 1237 b.h.p.+70 lb thrust, giving a consumption of 0·82 lb per equivalent shaft horsepower per hour.

Very great importance is now being placed on the provision of after-burning equipment, particularly for its thrust augmentation characteristics at great altitude. One reheat installation, that of the "RA 7 R" engine, will be shown by Rolls-Royce, Ltd., which increases by 2000 lb the static thrust of the "RA 7."

The Bristol Aeroplane Company will be showing non-sectioned marks of the "Olympus" turbo-jet engine and "Proteus 705" turbo-propeller engine.

The "Olympus" (Fig. 1) is stated to have been a very successful unit and as originally developed was rated at 9750 lb static thrust, but is now well in the 10,000 lb class. It was the first engine to run employing a compound fourteen-stage axial compressor, which consists of six forward stages driven by the second-stage turbine and mounted coaxially with the aft eight higher pressure stages, driven by the first-stage turbine. It has now a fully annular combustion chamber and succeeds in keeping down to an overall diameter of 40in. It is 124in long and weighs 3520 lb. The maximum rotor speed is 8000 r.p.m. and its normal fuel consumption of 0·76 lb per pound thrust per hour is comfortably lower than that reported for any other turbo-jet engine. An explanation of some of the advantages for the "double-spool" engine was given in our issue of July 4, 1952. One of the problems of operating an engine in this category is the power and the time taken to start, and with this engine it is an advantage that only the high-pressure stages, together with the first-stage turbine, need be accelerated in order to get the power plant up to its sustaining speed. The inertia and compression load is consequently much reduced and is not a demand beyond the capacity of an electric starter. Arrangements to produce this engine by the Wright Aeronautical Division of the Curtis Wright Corporation were announced last year. The Pratt and Whitney Division of United Aircraft Corporation is also now producing two dual-compression engines of its own design, one, the "J 57," rated at 9500 lb static thrust and the other, with after-burner equipment, rated at 12,500 lb. Another larger version, the "J 51," is under development in the 12,000 lb to 15,000 lb thrust class, but is not reported to have run.

The company is also to display a "Proteus 705" turbo-propeller engine (Fig. 5), an engine now in quantity production. It belongs to the much-improved "700" series of engines which has undergone considerable aerodynamic and mechanical modification from the original "600" series to which belong the prototype and the coupled versions. Its weight has been brought down from 1·18 lb per maximum equivalent shaft horsepower to 0·74 lb, and the cruising fuel consumption from 0·63 lb per equivalent shaft horsepower per hour to 0·48 lb per equivalent shaft horsepower per hour. On the other hand, the engine develops on take-off 3780 e.s.h.p., which includes 1200 lb thrust at the jet pipe as against the 2820 and 3150 e.s.h.p. of the earlier series. The compressor retains twelve axial stages with a modified single-sided shrouded impeller bolted to the twelfth stage, the compression ratio being raised to 7·2 : 1, the air mass flow to 42·5 lb and the maximum speed to 12,000 r.p.m. In the arrangement air flows forward through the compressor,

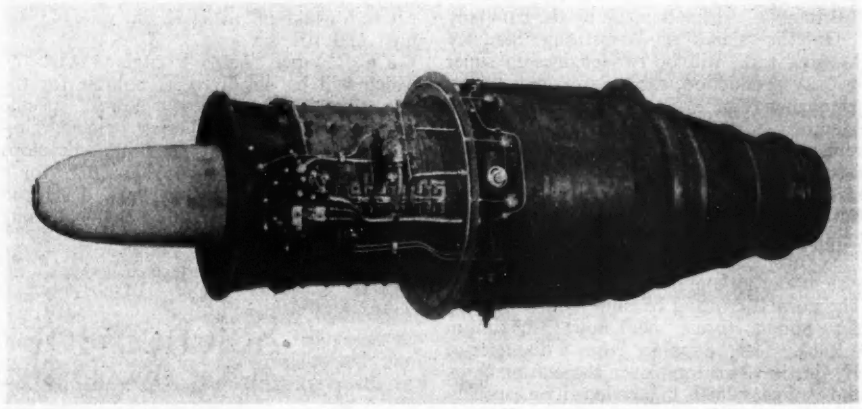


Fig. 7—The Armstrong Siddeley "Viper" Turbo-Jet Engine

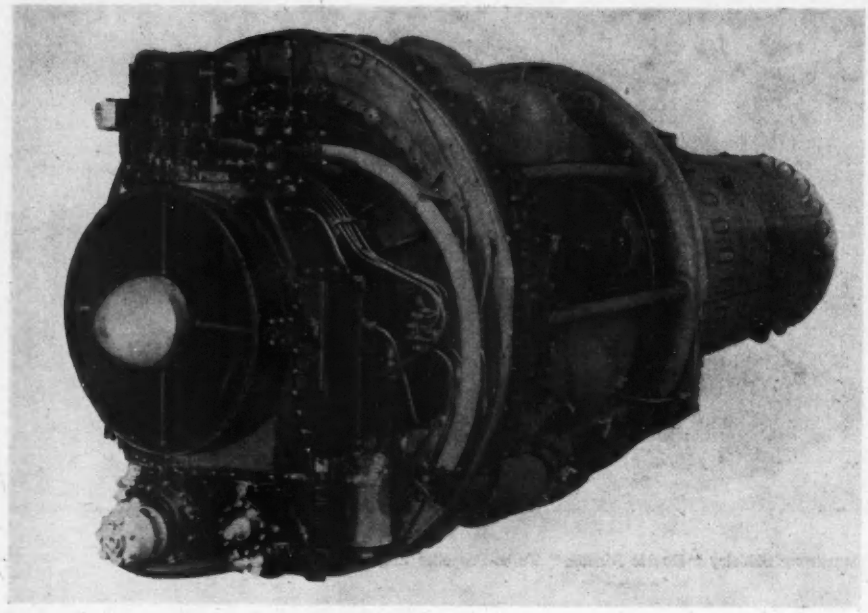


Fig. 8—The de Havilland "Ghost" Turbo-Jet Engine

is collected from the impeller in diffuser elbows, and turned through 180 deg. to pass through the eight combustion chambers. There is a fixed two-stage turbine driving the compressor and a two-stage free turbine mounted coaxially which drives a single four-bladed, constant-speed and reversing propeller through a 11·1 : 1 epicyclic spur reduction gear. The maximum cycle temperature is 845 deg. Cent. The engine is only 100·5in long with a diameter of 39·5in. Both this engine and a later model, the "755," which are under development at 4150 e.s.h.p., are to power the series of "Britannia" airliners made by the company

On the stand of Armstrong Siddeley Motors, Ltd., will be two engines in super priority production, the "Sapphire" turbo-jet engine (Fig. 3) and the naval "Double Mamba" turbo-propeller engine. The current production model, the "Sapphire 100" (Ass.a.6) was type tested at 8300 lb dry static thrust for take-off at 8600 r.p.m., but is rated at 8000 lb. The compressor employs thirteen axial stages and a two-stage turbine. It has a vaporising combustion system and an annular combustion chamber. The normal cruising consumption is 0·85 lb per pound thrust per hour (maximum 0·9 lb). The "Sapphire" has a diameter of 37·4in, is 134in long over the starter cone, and weighs 2600 lb, giving it a specific weight of 0·32 lb per pound thrust, which is also lower than that of any other axial engine reported overseas. It is fitted to the Gloster "Javelin" delta radar fighter, the Handley Page "Victor" bomber and to the Mark II version of the Hawker "Hunter."

The "Double Mamba ASMDI" turbo-propeller engine (Fig. 6) is fitted to the Fairey "Gannet" a carrier-based anti-submarine aircraft, and the main advantage of this power plant lies in its arrangement. As its name implies, it consists essentially of two "Mamba" engines mounted side by side each output shaft driving through reduction gear to independent coaxial propeller shafts with the propellers contra-rotating. Because of the poor part load characteristics of the gas turbine the aircraft can thus, to obtain maximum range, operate on one engine alone under its optimum cruising conditions, with the other shut down and its propeller feathered. The aircraft consequently has the facility of a twin engined machine without its normal disadvantages which are particularly desirable for a naval aircraft operating over the sea at distance from its carrier should one engine become unserviceable. Each power section is substantially identical to the "Mamba 504 ASM3" unit, which has a ten-stage axial compressor, a two-stage turbine, six combustion chambers, weighs 780 lb and develops 1475 e.s.h.p., the cruising consumption being 0·77 lb per effective shaft horsepower per hour. The combined plant weighs 2125 lb and develops 2950 e.s.h.p. (includes 810 lb jet thrust) at 15,000 r.p.m. for take-off. It is 52·8in wide, 43·8in high and 101·8in long.

The "Viper ASV3" engine (Fig. 7), which will be displayed, is notable for the fact that it possesses the lowest specific weight of any turbo-jet engine reported. This relatively small unit develops 1640 lb static thrust at 13,400 r.p.m. for a weight of 365 lb. It has been developed primarily as a short-life engine, using materials consistent with this requirement, for target and guided missiles, and is in production for the radio-controlled "Jindivik" aircraft used in Australia. A longer-life version, the "ASV5," is also being produced for the Percival "Provost" intermediate trainer aircraft. The "ASV3" has a seven-stage axial compressor, a one-stage turbine and an annular combustion chamber with the vaporising combustion system used on all the company's projects. This unit has a diameter of 23·2in and is 65·4in long.

The company has been producing for some time the "Python" turbo-propeller engine which powers the Westland "Wyvern" naval aircraft. This was the first turbo-propeller engine to be placed in production and was at one time the most powerful. It develops 4110 e.s.h.p., which is now exceeded by the American Pratt and Whitney "T.34, P.2" turbo-propeller of 5700 e.s.h.p., which is in small-quantity production.

Amongst the engine exhibits of the de Havilland enterprise will be a set of components of the "Ghost" centrifugal turbo-jet engine, which have averaged 1000 hours of duty in B.O.A.C. "Comet" service. This engine now has an overhaul life of 600 hours. The "Ghost 50," Mark I is the commercial version of the engine and has a cruising fuel consumption of 1·02 lb per pound thrust per hour, which indicates the major disadvantage of the centrifugal engine compared with the axial engines. It has a single-stage, single-sided impeller and operates with a single-stage turbine at 10,250 r.p.m. and 800 deg. Cent. gas temperature, and develops 5050 lb static thrust, which is increased to 5600 lb with water injection. A military version, the "103R," has a two-position afterburner giving an additional 1550 lb static thrust.

No further information has been provided of the "Gyron" axial-flow turbo-jet engine since its announcement last month and it will not be seen at the static display. It has been reported in America as being on the 15,000 lb thrust class but whether, as with the "Olympus" or the Pratt and Whitney high-thrust units, it has a compound compressor is not indicated. The company stresses that the design possesses "exceptional simplicity."

(To be continued)

Science for its Own Sake

By SIR EDWARD APPLETON, G.B.E., K.C.B., F.R.S.

The main part of the author's Presidential Address to the British Association at Liverpool, delivered last Wednesday, was concerned with research into the origins of cosmic radio noise. What he had to say upon that subject was prefaced by the words we print below which, though relating to pure science, have relevance also to the work of engineers.

THE subject of my address was chosen to emphasise something that, at times, is in danger of being overlooked, namely, that science has interest as well as utility—that science is illuminating as well as fruitful. Having spent ten years of my own life in seeking to further the applications of science in the practical life of our country, I do not think I can be accused of under estimating the vital importance of science as an instrument of material utility. I have long held the belief that the cost of scientific research is the price we must pay for our industrial progress, But we should be misleading the public, as well as ourselves, if we based our case for the general support of the pursuit of science on its utilitarian aspects alone. I know that we can claim that many discoveries in pure science, which in their time had no obviously practical import, have later proved to be the foundations of major improvements in our material civilisation. But even that is an argument of profit and loss, and, to my mind, does not bring us entirely to the heart of the matter. I should like to go back, beyond the achievements, to the example of the scientist—be he amateur or professional—who is impelled solely by a passionate desire to explore and understand. That is what I mean by science for its own sake—when knowledge and insight are sufficient reward in themselves. Can the pursuit of a scientific vocation of this kind be a way of living worthily ? Can it, in

Dr. Johnson's phrase, help to advance us in the dignity of thinking beings ? What values for us as individuals does it propound ? As well as theoretical knowledge, as well as material benefit, is there some deeper, if more intangible, thing, even wisdom itself, to be found in our vocation ?

I certainly make no claim to be able to provide the right, or the only, answers to such questions. At the most I simply hope to indicate to you where I think some of the value of a scientific vocation lies. After the extravagant claims that have sometimes been made on behalf of science—claims which have had the disagreeable consequence of putting the scientist on a pedestal —it is well that we should walk humbly. And yet, all the same, in a time of uncertainty of values and lowering of ideals, it is important that we should own to what we believe.

Now I begin by attempting to get the setting right, by pointing out that we scientists do not really inhabit the kind of universe which has sometimes been attributed to us. Science has so often been accused of having reduced the beauty and mystery of the universe to something cold and mechanical. When science enters the door, enchantment, it has been said, flies out of the window. You will remember the lines of the poet Keats :—

> "There was an awful rainbow once in heaven :
> We know her woof, her texture ; she is given
> In the dull catalogue of common things."

Now it is fairly easy to see how this attitude came about. The world of what is now called classical physics, as it was mapped out for us from the time of Newton onwards, had the advantage of appearing comfortably solid and tangibly final. Anyone, it seemed, who could understand why an apple falls from a tree could also understand the stars in their courses. In this light the universe might well seem to a poet to fail to come up to his expectations. We now know how misleading it was to regard this account of the matter as final. Perhaps the most striking fact about modern science, in its explorations ranging from the heart of the atom to the frontiers of the universe, is that, like poetry, like philosophy, it reveals depths and mysteries beyond—and, this is important, quite different from—the ordinary matter-of-fact world we are used to. Science has given back to the universe, one might say, that quality of inexhaustible richness and unexpectedness and wonder which at one time it seemed to have taken away from it. "The world will never starve for want of wonders," says G. K. Chesterton, "but only for want of wonder."

I hope to try to illustrate all this in a moment from the fields of cosmical research which have been my own interest for many years. But just now one general point I want to emphasise is that the scientific approach to things is a far more personal and imaginative activity than is sometimes realised. I am ready to admit that deliberate application to discovery can often take us some distance ; also that important progress can result from the operation of a team of workers, as distinct from an individual, though this is mostly the case when the follow-up or consolidation of a basic discovery is in question. But the big jumps ahead are usually the adventures and intuitions of a single mind.

I need hardly remind such an audience as this that scientific activities are twofold. We can make observations and experiments —that is to say, gather facts. And we can also seek to understand how the facts fit together. We express any order we can discern among the welter of facts in the form of a hypothesis or a theory. A theory, by the way, is only a hypothesis that has become, so to speak, respectable. But even then there is nothing final about it. As J. J. Thomson once said, a theory is a policy rather than a creed.

Now, even in this question of making observations, the scientific process is one which requires the fullest and subtlest employment of all our faculties. It demands, for example, that we should not only see things, but should notice them ; and not only notice, but perceive them. Many a vital discovery has been nothing else than recognising the unexpected. To encounter Nature in this necessary state of awareness is inevitably to find all its forms and movements, from the infinitely small to the infinitely large, full of inexhaustible significance and relevance. But even in experimental work it is the primacy of an imaginative idea or intuition that often starts it all off. In simple words, I might say that the important thing in experimenting is to ask Nature the right question and in its most direct form. Only then is the answer clear and unmistakable. But so often one has failed to ask the right question and the terms of it have to be recast. In this complex process it is as if knowledge were playing a game of chess with the mind, and one has to be constantly on the alert with fresh tactics or even a changed strategy.

Many of our questions turn out to be wrong because they are unanswerable, but it is only by asking them at all that we eventually find we have asked the right one. And one knows how oddly, how unreasonably I might almost say, the right question has often flashed into men's minds. It was recorded by the German physicist Helmholtz that his best ideas only came to him when he was walking up a slowly ascending street —and significantly enough he was one of the founders of the principle of the conservation of energy ! What I do know, from my own experience, is the fruitlessness of pondering over a scientific problem too long. The mind gets polarised and thought becomes captive to a groove. How often the best way of solving a scientific difficulty is to leave it alone ! Also, speaking as a professional scientist who has only recently turned amateur, I would like to acknowledge the immeasurable debt which science owes to members of the latter category. My own subject of radio-physics has, on many occasions, been advanced by the observations of the gifted and enthusiastic amateur who was able to recognise the unexpected, even if his professional skill was insufficient to enable him to reveal its full meaning and implication.

Asking Nature the right question in the right way—or recognising a theoretical pattern in a tangled skein of experimental data—often has the effect of introducing an element of beauty and elegance into the scientist's work. Do we not, on occasion, refer to a "beautiful theory" and an "elegant experiment" ? It is perhaps a little difficult to say what precisely we mean by this. Not, I think, that the theory or the experiment is necessarily conclusive or irrefutable, or even particularly fertile in its consequences—that would be virtue of another kind. The quality I have in mind is that of inevitability—and yet, paradoxically enough, an inevitability which can cause surprise ! A great experiment seems to us, somehow, something which could not have been done differently. Or, if it had, something essential would have been lost. We are surprised that someone thought of doing it that way, but we can see now that that way is really the only way to do it. Taking away something, or adding something, only detracts from it. In this respect a beautiful experiment can surely be classed with a great work of art.

Now I have spoken in general terms of the scientist's approach to Nature and of the kinds of mental quality and awareness that science requires in its followers. And I have tried to suggest that the exercise of these skills has a value in itself which is ample justification of a scientific vocation. To go further might be claiming too much. And yet, I wonder. If we think of the great figures of science and, to be fair, restrict ourselves only to those we have known intimately, can we not go further and say that the scientific vocation, by its very nature, calls for personal qualities that deserve to be recognised and honoured ? I might point, for instance, to that tolerance and open-mindedness to new ideas which shines even from the printed page of Rutherford's Address to this Association when he was president here thirty years ago—that freedom from prejudice, muddle, hypocrisy and darkening of counsel which characterised the man many of us were so privileged to know.

An Optical Follower for Milling Machines

PARTICULARS have been received from Salisbury Precision Engineering, Ltd., Castle Road, Salisbury, of an optical follower unit it is now making for attachment to vertical and universal milling machines to adapt them for the precision spacing of holes in components.

The instrument consists essentially of a vertically mounted microscope which is supported on a horizontal arm from a pillar attached by a bracket to the machine knee. The microscope has cross hairs set at 90 deg. and a thirty-two times magnification. It is used in conjunction with a precision scribed template which is attached to one end of the machine table clear of the working area. On this template the position of the holes it is required to bore in the component or workpiece are first scribed in the conventional way by means of a height gauge or similar equipment.

When using the instrument the relative positions of the template in respect to the microscope, and the workpiece in respect to the axial centre of the tool, are first set. Between subsequent machining operations the table of the machine is moved in accordance with the template markings as seen through the microscope, and no further adjustments need be made to the optical follower, and no measurements are required. As the follower is attached to the machine knee its focus is maintained even though the knee may be moved up and down. Tools can be changed for a sequence of operations on each hole without in any way impairing the accuracy of operation. For each hole the operator simply adjusts the table to place the cross hairs of the microscope over the cross lines scribed on the template, and, if necessary, he can return repeatedly to the centre of holes already machined for other operations.

The initial setting of the microscope in respect to a template is facilitated by its three adjustments. A rack and pinion focusing of the microscope tube provides for focus and vertical movement over the template. A screw adjustment gives lateral motion to the microscope body tube, and there is a rack and pinion adjustment on the horizontal cross arm bracket which can be used to give a rough in and out setting over the template. On its pillar the cross arm has a 9in adjustment and swing from side to side. Two lights are arranged on the microscope body to illuminate the point under the cross hairs. To facilitate rapid location without looking through the microscope on the template a locating wire is suspended from a steel ring on the microscope objective lens. This wire enables an operator quickly to reposition his table between working points before making his precision setting.

Aluminium Inspection Launch

On Monday of this week an aluminium launch, which has been built by Grimston Astor, Ltd., arrived in the Thames, having made the voyage from Bideford under her own power. Later in the week the craft was put on board the "Karmala" for shipment to Pakistan, where she will be put into service on the Pussar river to carry out inspection duties on behalf of her owners, the British India Steam Navigation Company, Ltd.

The photograph reproduced on this page gives a general impression of the external appearance of the launch, which has the following particulars: length overall 40ft, length on water line 39ft, breadth 12ft, service draught 2ft 9in, and displacement 4·5 tons. This twin-screw boat has been constructed of aluminium alloy supplied by the British Aluminium Company, Ltd., on the Grimston Astor "Two-way tension system," which was described in THE ENGINEER of February 23, 1951. It allows the shell of the boat to be prefabricated in the flat unstressed condition after which it is pulled upwards about the centre line to conform with shape as predetermined by the lines plan, so that thinner sheet can be used with a resulting reduction in hull weight and other cumulative effects. The double curvature imparted to the flat sheet gives it an increased resilience due to the strain energy absorbed by the material. There are six compartments and these, starting from forward, consist of a forepeak store and chain locker and a stores compartment which is fitted with a "Kepcold" ice-box. This store opens into the saloon, which has a raised roof and is fitted with a settee, to port and starboard, having lockers underneath and of a size sufficient to provide seating accommodation for twelve passengers.

Aluminium Inspection Launch

Immediately aft of the saloon and arranged at a higher level is the cockpit which contains the steering controls and is fitted with a bench seat on either side at the after end. Further aft is the engine-room, to which direct access is gained from the after cabin, which forms the crew's quarters. A yacht windlass with detachable lever and sprocket wheel is mounted forward to handle the two Danforth anchors, one of 43 lb and one of 30 lb, and 30 fathoms of $\frac{5}{16}$in chain cable. Steering is effected by direct flexible wire cables connected to the rudders, and engine control is by Teleflex double lever gear. Two 10-gallon capacity tanks provide the fresh water supply and there is a bilge pump fitted outside the cockpit, while fuel is carried in a tank of 187-gallon capacity located in a compartment aft of the crew space.

Power for driving the launch is supplied by two Perkins S.6.M diesel engines, each of which is rated to develop 100 b.h.p. at 2000 r.p.m. These six-cylinder engines have a bore and stroke of 4$\frac{1}{8}$in by 5in, are equipped with oil-operated reverse gearboxes, and drive three-bladed light alloy propellers, mounted on stainless steel propeller shafts through "Silentbloc" marine flexible thrust couplings. Electrical starting is employed and power is obtained from two 24V batteries of 130 a.h. capacity.

Full power and steering trials were carried out in July and at full speed the boat had a turning circle of 60ft diameter under either helm, of 40ft diameter with one engine stopped and practically pivoted on her own axis with one engine going astern. Four runs were made over the harbour half-mile at slack water, high tide, with a south-westerly wind of force 5–6 and with the engine speed maintained at 2000 r.p.m. an average speed of 20·77 knots was obtained. Since the vessel was not in suitable trim for carrying out further trials over the Admiralty half-mile, in conditions of a strong south-westerly wind and short light sea, further runs were made inside the harbour to a final average speed of 20·79 knots and engine speed of 2000 r.p.m.

Diesel Engine Tests

Since 1949 the diesel engines manufactured by Fodens, Ltd., have been undergoing type tests and extended endurance trials at the Admiralty Engineering Laboratory, West Drayton, and we have received from the company some of the general results of the trials. In the course of these tests one of the company's six-cylinder engines has been on trial. This is a supercharged uniflow scavenged two-stroke compression ignition engine based on the Kadenacy principle having six cylinders in line, with a bore and stroke of 85mm by 120mm, and a compression ratio of about 14 to 1 and developing 105 b.h.p. at 1800 r.p.m.

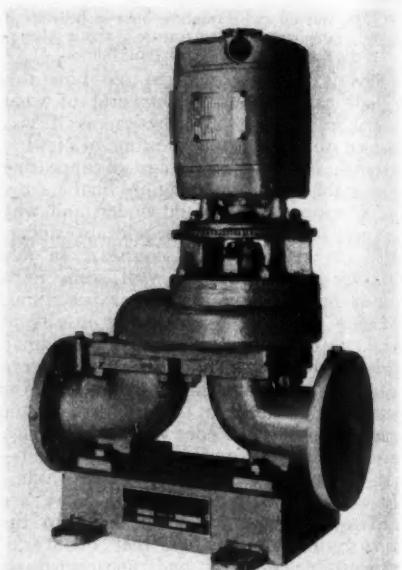
The tests extended over 11,500 hours and measurements showed that the wear on the crankshaft main and big end bearings was less than 0·001in, while the liner wear was under 0·0005in per thousand hours. After 4000 hours of running the piston rings were still serviceable and the consumption of lubricating oil was maintained throughout at an amount considerably less than 1 per cent of the fuel consumption. As the tests proceeded they became progressively more severe and the initial series of 500-hour endurance runs were made on a twenty-four-hour load cycle at 1800 r.p.m. at the full load of 100 b.h.p. and included one period at 10 per cent overload. Following this was a 500-hour test with the speed and load varied to produce the worst possible conditions, runs being made with periods of low load combined with low speed alternating with high load and high speed.

Having successfully completed these tests, a run of 4000 hours was undertaken at 100 b.h.p. at 1800 r.p.m. with periods of overload. This was followed by a 2000-hour run at 113 b.h.p. at 1800 r.p.m. with overload periods and another run lasting 2000 hours at 113 b.h.p. with overload in a simulated tropical temperature of 115 deg. Fah. The standard engine is designed to start at temperatures down to 20 deg. Fah. and cold starting tests demonstrated that certain starting at this temperature was possible without use of external aids, using standard fuel and lubricating oil and standard electric starting.

Accelerator Pumps for Low-Pressure Heating Systems

We illustrate below one of a series of Fullway accelerator pumps manufactured by Ryaland (Manchester), Ltd., for low-pressure hot water central heating systems. They are fitted with single or three-phase Hoover motors in $\frac{1}{4}$ h.p., $\frac{1}{3}$ h.p. or $\frac{1}{2}$ h.p. sizes, according to the varying duties for which the pumps are required.

These pump units are fitted with special sealing arrangements instead of the ordinary stuffing-box. The seals, it is claimed, run with freedom from trouble and require no attention. Furthermore, this arrangement provides a protection for the Hoover electric motors since the motors cannot be overloaded.



Accelerator Pump

In all sizes, these units are designed in a manner which provides full pipe bore area throughout the volute and pump casing. Thus, even when the pump is not running, systems can operate by gravity since there is no friction set up by the design of the pump. In the larger sizes the inlet and discharge branches can be rapidly swung at right angles instead of being in line as shown in the illustration. There are no bearings in the pump which require lubricating.

The Use of Industrial Films.—Five "industrial sessions" are included in the programme of the annual congress of the International Scientific Film Association which is to be held at the Royal Festival Hall, London, from September 22nd to 25th. These industrial sessions will consider the international use of films for industrial research, vocational guidance, training and welfare, and work simplification methods. A certain number of guests will be admitted to these sessions and application for full details and invitations should be addressed to Mr. J. Stewart Cook, the Scientific Film Association, 164, Shaftesbury Avenue, London, W.C.2.

The Harlan County Dam in Nebraska

(By Our American Correspondent)

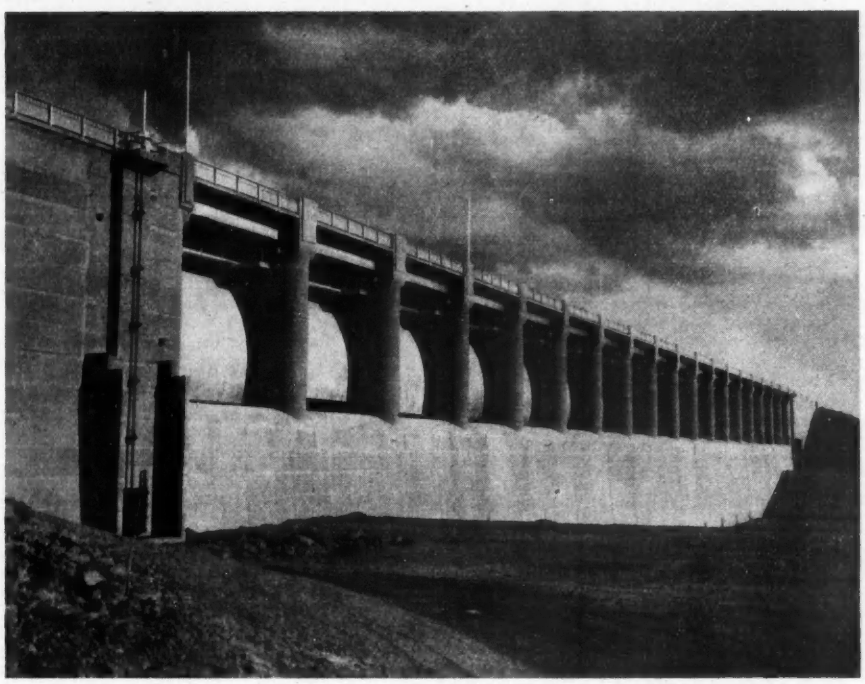
Construction of the Harlan County dam and reservoir on the Republican River in Nebraska has now been largely completed. The 11,830ft long structure is an important unit in the Pick-Sloan plan for the Missouri River basin and will provide both flood control and irrigation benefits. Unlike the five principal multiple-purpose dams now being constructed on the Missouri River, the Harlan County dam will generate no hydro-electric power for the time being.

THE Harlan County dam and reservoir was designed primarily for the control of floods in the Republican River basin as a unit within the comprehensive plan for flood control on the Kansas and Missouri Rivers and their tributaries. The multiple uses of the project consistent with the primary purpose of flood control will include irrigation, public health, recreation, and fish and wild life preservation, and a bulkhead opening has been provided in the dam to permit a possible future installation of power generating facilities. As shown in the accompanying map, the scheme is situated in the south-central portion of the State of Nebraska, close to the border between Nebraska and Kansas. The dam site is about 8 miles east of Alma, the county seat of Harlan County. The construction of the dam and reservoir was originally authorised by the Flood Control Act approved by Congress in August, 1941. After certain revisions the final scheme was included as a unit in the comprehensive plan for the Missouri River basin and was authorised by the Flood Control Act approved in December, 1944. The project was constructed by the U.S. Army Corps of Engineers, with the co-operation of the U.S. Bureau of Reclamation and local agencies. Construction of the earthfill embankment began in August, 1946.

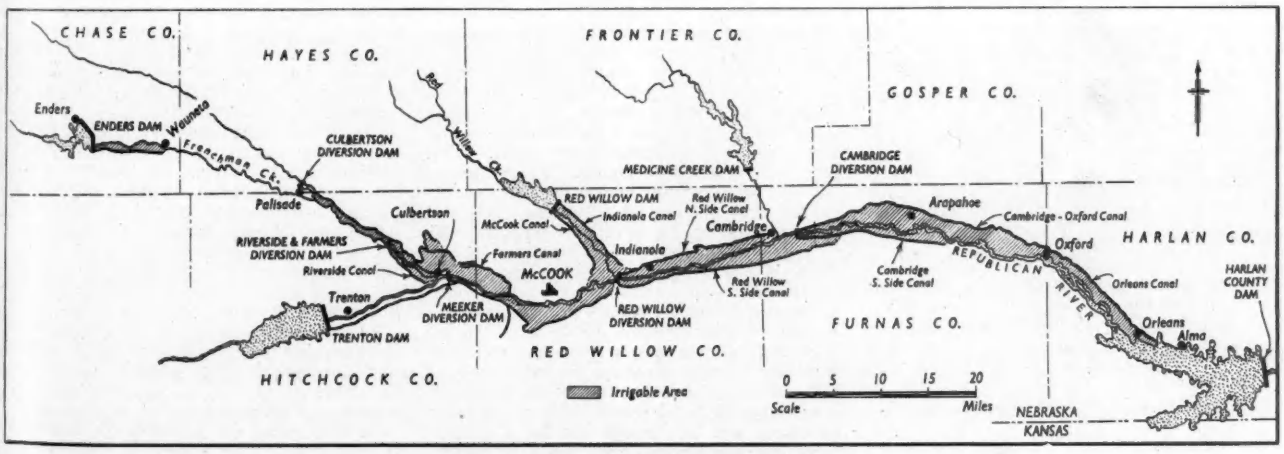
The Republican River is formed by the confluence, near Haigler, Nebraska, of the Arikaree River and the north fork of the Republican River, both of which rise in Eastern Colorado. Flowing generally easterly and south-easterly, the Republican River joins the Smoky Hill River immediately below Junction City, Kansas, to form the Kansas River. The catchment area downstream from the dam is comparatively narrow, averaging about 30 miles in width, and the tributaries in this section are relatively short. Upstream, the catchment widens to a maximum width of about 120 miles, and the tributaries there are of substantial length. The catchment area above the Harlan County dam is 20,753 square miles, constituting about 83 per cent of the total area of the Republican River basin. Downstream from the dam the basin is characterised by well-defined stream channels with gently rolling uplands. Deep, precipitous side walls in the downstream portion give way to more gently sloping valley walls in the vicinity of the dam. Tree growth, is, in general, restricted to areas adjacent to watercourses.

The normal annual rainfall for the Republican River basin above the dam is 19·9in, ranging from 24in at the dam to 17in in the western end of the basin. The maximum annual rainfall over the basin was 32·3in in 1915, and the minimum 10·2in in 1894. The flood which occurred in the spring of 1935 is the largest flood recorded on the Republican River, the maximum instantaneous discharge during that flood having been estimated at 260,000 cusecs. During the period of May 28 to June 10, 1935, the volume of run-off at Bloomington, Nebraska, was 480,000 acre-feet. Flood history also shows that the majority of the floods of record on the Republican River have occurred between May 15th and July 15th. Data taken from the 1940 United States Census show that 49 per cent of the farming area in the Republican River basin above the Harlan County dam is arable, and 11 per cent pasture. The remaining 40 per cent was classified as pasture land other than arable, waste land and non-agricultural land. On the whole the upland area is comparatively level, and includes numerous shallow basins or depressions, in which the run-off is collected and retained until absorbed or lost through evaporation. It is estimated that an area of about 6200 square miles has no apparent surface outlet for drainage.

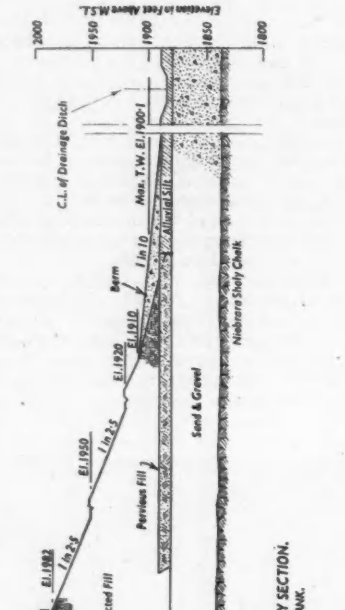
The operation of the Harlan County dam scheme will be by joint agreement between the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation. The flood control and irrigation schemes of the Bureau of Reclamation in the Republican River area upstream of the Harlan County dam are also indicated on the accompanying map. The current development plan of the Bureau for what is known as the Frenchman-Cambridge irrigation district includes the construction of three multi-purpose storage dams, four diversion dams, five main canals, the extension of two existing canals, and laterals and drains to irrigate an area of approximately 53,140 acres along the Republican River in Southern Nebraska. The three storage reservoirs with earthfill dams will allow irrigation storage, flood control and silt retention. They are the Enders dam and reservoir, the Medicine Creek dam and reservoir, and the Trenton dam and Swanson Lake reservoir. Water released from the Enders reservoir into the Frenchman Creek is diverted into the Farmers Canal and the

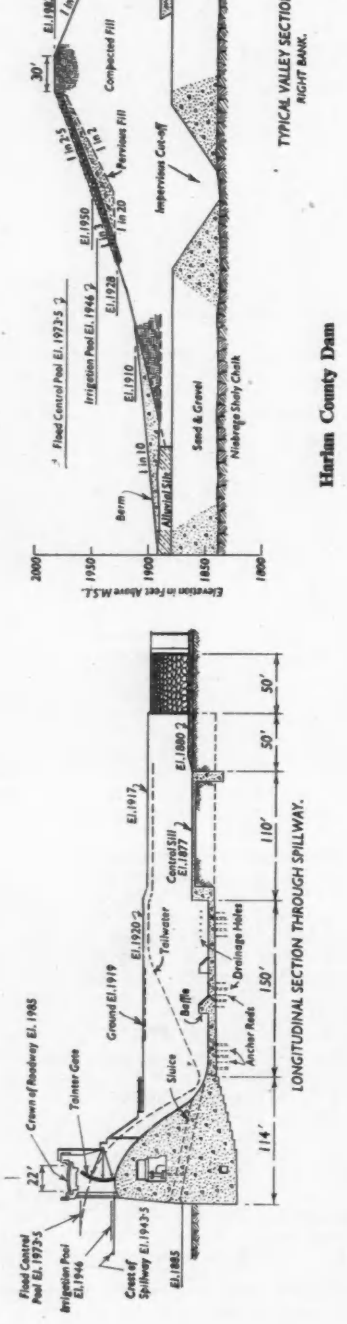


Spillway from Upstream



Map of Works on the Upper Republican River





Harlan County Dam

Riverside Canal. The system of diversion dams and irrigation canals extending downstream from this point are clearly shown in the illustrations, the lands which they irrigate being shown dotted. All the four diversion dams of the Frenchman-Cambridge scheme—Riverside and Farmers, Meeker, Red Willow diversion, and Cambridge dams—are reinforced concrete structures having "ogee" overflow crests controlled by radial gates and each has a spillway capacity of 50,000 cusecs. The principal data relating to the three main earthfill storage works of the scheme are given in the following table :—

	Enders dam	Medicine Creek dam	Trenton dam
Total height, feet	103·5	115	144
Crest length, feet	2,603	5,665	8,900
Crest width, feet...	30	30	30
Spillway capacity, cusecs	200,000	97,800	133,000
Normal reservoir capacity, acre-feet	44,500	40,000	122,800
Length of reservoir, miles... ...	5·5	8·5	6
Completion of dam	1950	1949	1952

Downstream of the Harlan County dam, about 96,000 acres of land lying in the Republican River Valley and on the flanking lands in the States of Nebraska and Kansas between the dam site and the town of Concordia, Kansas, are being developed within the Bostwick irrigation scheme of the Bureau of Reclamation. Irrigation water for this land, which is now mostly dry-farmed, will be obtained from storage in the Harlan County reservoir and will be delivered to the farms through two canals from the Harlan County dam, three concrete diversion dams on the Lower Republican River and four pumping plants.

Structural Design

The Harlan County dam consists of a rolled-fill embankment with a centrally situated concrete overflow spillway section, as shown in the accompanying sectional drawings. The two parts of the embankment have a total length of approximately 10,480ft, and the spillway and bulkhead section is 1350ft long, making a total length across the valley 11,830ft. About 13,400,000 cubic yards of selected fill was utilised in the construction of the embankment. The crest elevation of the dam is 1982ft and its height is approximately 107ft above the stream bed. The base width of the dam, excluding the berms, is 750ft and the crest width is 30ft. A 22ft wide paved roadway extends across the crest of the dam. The side slopes of the rolled-fill sections vary from 1 in 2½ to 1 in 6, with 1 in 10 slopes in the berm sections. The upstream face of the dam, between elevation 1928ft and the crest of the dam, has been protected from wave erosion by a 3ft covering of stone riprap placed on a 1ft layer of graded spalls, which in turn is placed over a sand cushion with a minimum thickness of 1ft. To minimise the seepage of water through the foundation sands under the dam a trench was excavated across the valley and backfilled with rolled impervious fill to form a cut-off. The foundation for the spillway and bulkhead sections has been stabilised by pressure grouting where necessary.

The illustration on page 313 shows the completed spillway with its gated "ogee" crest overflow section 856ft long. The fixed crest elevation of the spillway is 1943·5ft and the total height of the spillway section from the rock foundation to the crown of the roadway on top of the spillway is approximately 150ft. The flows are controlled by eighteen Tainter gates, each 40ft wide by 30ft high and separated by piers 8ft in width. The discharge capacity of the spillway at full pool level of 1973·5ft is 431,000 cusecs.

The release of flood control storage will be through nine sluices, each 5ft wide by 8ft high, with upstream inverts situated at an elevation of 1885ft. The capacity of the nine sluices varies from 20,600 cusecs when the reservoir water level is at the top of the flood control pool to 15,100 cusecs at the bottom of the irrigation pool. Irrigation water releases of approximately 200 cusecs will be through the flood control sluices, and also through one conduit 2ft 10in in diameter situated in the left bulkhead section and another conduit 2ft 10in in diameter in the right bulkhead section.

Water Control

The primary function of the dam is the flood control of the flow of the Republican River to effect the maximum practicable reduction in flood damage on the Republican, the Kansas and the Missouri rivers with incidental reduction in flood damages on the Mississippi. At the present time the allocation of reservoir storage is as follows :—

	Acre-feet
Flood control	500,000
Irrigation, conservation and silting	350,000
Total	850,000

Normally the water level in the reservoir will be maintained within the irrigation pool. At full irrigation pool the storage of 350,000 acre-feet forms a 13,600-acre lake, 12 miles long and with a shore line of 58 miles. The flood storage capacity of 500,000 acre-feet is provided above irrigation pool level. The entire flow of the Republican River during the disastrous flood of 1935, which was of unprecedented proportions, could have been stored with a margin of safety above the irrigation pool in the reservoir. At capacity storage, a condition which would result only in event of the "project design" flood, the water in the reservoir would cover 22,800 acres and would extend upstream about 15 miles to Orleans, Nebraska. Under normal operating conditions, excepting flood control, the annual fluctuation of the water surface level in the reservoir will be about 9ft. Observations which have been made at other reservoirs which have similar fluctuations indicated a rather extensive development of recreational and wild life facilities, and wild life conservation and the full utilisation of recreational facilities at the reservoir are being encouraged.

The total cost of the Harlan County dam and reservoir has been about 47,000,000 dollars, all of which was borne by the Federal Government. The annual benefits arising from the completed scheme are estimated to be worth 2,380,000 dollars, of which 1,662,000 dollars will accrue from the prevention of flood damages. In the event of a single occurrence of the "project design" flood it is estimated that the dam and reservoir would prevent total flood damages in the region of 12,000,000 dollars. Annual benefits from irrigation are estimated at 718,000 dollars. In addition to such direct benefits, those accruing from other uses of the reservoir area, including the leasing of land for crop production or grazing, recreational activities, public health, enhancement of fish and wild life, and improved downstream water conditions, will be substantial. The Harlan County scheme was constructed by the U.S. Army Corps of Engineers and the main construction contract was handled by the Harlan Construction Company.

Fourth Anglo-American Aeronautical Conference

The Royal Aeronautical Society has announced some details of the functions and lectures which it has arranged for the forthcoming Anglo-American Conference starting on September 8th and ending on September 18th. It has been arranged that during the first two days delegates will be able to see the S.B.A.C. Flying Display and Exhibition at Farnborough, followed by visits the next day, Thursday, to Rolls-Royce, Ltd., Derby, and to Vickers-Armstrongs' works at Weybridge on Friday. On Monday morning and afternoon, September 14th, a visit has been arranged to Handley Page, Ltd. At 6 p.m. the Wilbur Wright Memorial Lecture will be read at Friends House, Euston Road, followed by a reception at 4, Hamilton Place, W.1. The lecture programme commencing on Tuesday, September 15th, gives notice of twelve lectures which will be read in the Friends House. The morning paper on Tuesday is by Mr. H. L. Hibbard on "Structures for High Speed Aircraft," and in the afternoon Mr. G. S. Schairer will read a paper on "Pod Mountings of Jet Engines."

On Wednesday the following six papers will be read followed by a film on "Some Crash Fire Studies" : "Power Plants for Helicopters,"

by Captain A. G. Forsyth ; "Structural Adhesives for Metal Aircraft," by Dr. N. A. de Bruyne ; "The Control of Flight," by Mr. P. R. Bassett ; "The Aerodynamics of Compressor Blade Vibration," by Mr. H. Pearson ; "Aircraft De-Icing by Thermal Methods," by Mr. J. L. Orr, Mr. D. Fraser and Mr. J. H. Milsum ; "Some Factors Affecting Helicopter Design and Future Operations," by Mr. R. H. Miller.

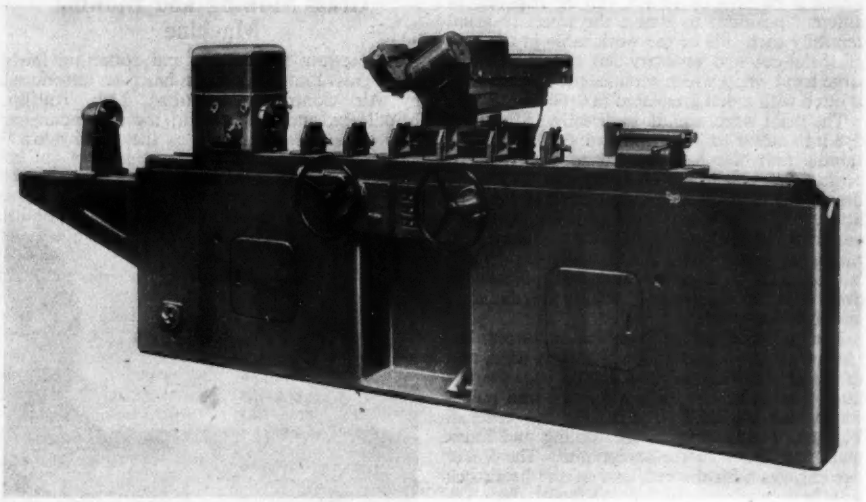
The lecture programme is concluded on Thursday with four lectures : "Recent Advances in Circulation Control," by Mr. C. W. Perkins and Mr. D. C. Hazen ; "Basic Pre-requisites for Production," by Mr. R. A. Neale ; "Some Observations on the Problem of Fatigue of Aeroplane Structures," by Mr. R. V. Rhode ; and "The Introduction of the 'Comet' into Service," by Mr. A. C. Campbell-Orde. The last day of the conference, Friday, September 18th, is to be devoted to a visit to the Bristol Aeroplane Company at Filton.

A Telescopic Body for Lorries

DURING a recent visit to the works of Walker Brothers (Wigan), Ltd., we saw under construction a number of the firm's "Jecta" telescopic lorry bodies which are distributed through an associated company, Walkers and County Cars, Ltd., 76, Grove Park Road, London, W.4. The use of this design of telescopic, self-discharging body has been steadily increasing and 40 cubic yard capacity bodies, which have been supplied for refuse disposal purposes, are believed to be amongst the largest self-discharging vehicles yet made.

The design of the "Jecta" body and its simple method of operation can be seen from the illustrations of a 20 cubic yard municipal unit which we reproduce. The body consists essentially of a number of U-shaped sections of ¼in sheet steel, as illustrated, or of rectangular shape in aluminium for special purposes. Each section is designed to telescope and "nest" within the section behind, the largest section being rigidly mounted at the end of the vehicle chassis. According to the duty and required capacity of a vehicle it is fitted with a three, four, or five-section body. In operation the foremost section is pushed rearwards, and as the sections telescope the contents of the body are discharged from the back of the vehicle.

The closed end of the front, and smallest, section of the body forms a rearward sloping bulkhead, the bottom edge of which is arranged to be flush with the rearmost end of the final fixed section at the end of the discharging movement. This bulkhead serves to sweep each section clear of its contents as it moves rearwards. At its front end each moving section is supported on a pair of rollers which run on rails mounted on the vehicle chassis side members. The rear end of each section rests on its neighbouring section and has a sealing strip attached to the edge. This sealing strip, in addition to supporting the section and half its load, effects a joint and cleans the body sides as it moves rearwards.



Hydraulically Operated Broach Sharpening Machine

The front section is pushed back by a hydraulic ram and it successively operates each of the intermediate sections until the discharging operation is completed. The ram has two double-acting extending sections and is supplied with fluid under pressure by a hydraulic pump driven from the vehicle power take-off. A two-way valve on the driver's cab is used to control movement of the body sections through a single lever. When five sections are used a hydraulic ram unit operates through a multiplication system of wire ropes to give the necessary length of travel.

The sections have open tops, but, if required, outer casings can readily be fitted to enclose the body and its contents, and any suitable type of rear door can be fitted to the body. When one of these bodies is used for the transport of packaged goods it is necessary that the sections shall move in sequenced order if the goods are loaded at and removed from the rear of the vehicle. For this purpose the makers have developed a special sequency gear incorporating side rods, pins and catches.

Broach Sharpening Machines

THE illustration at the head of this page shows a new sharpening machine for round, flat and spiral broaches, which is now being made in three models by the Coventry Gauge and Tool Company, Ltd., Coventry. One model of the machine is manually operated and can be used for sharpening round broaches only. A second manually operated machine is suitable for handling both round and flat broaches, whilst the third machine for round and flat broaches is fitted with a pedal-controlled hydraulic power cross movement. It is this third design of machine we illustrate above, but the two other machines are of similar general construction.

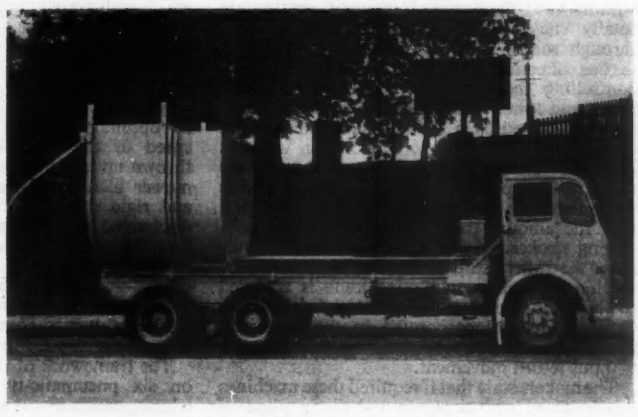
The work slide of the machine is carried on a substantial rigid base in which there is a knee recess to enable the operator to sit whilst he is at work. The slide can be mounted with fixtures or a magnetic chuck for flat broaches or a headstock and tailstock when used for sharpening round or spiral broaches. At the rear of the base there is a balanced vertical slide on which the wheel head unit is mounted.

The controls for the machine are conveniently grouped by the knee hole. One large hand wheel on the operator's left is fitted with a fine feed motion and actuates the work slide, and a similar large wheel on his right has a graduated dial and controls the elevation of the wheel head. Three sets of push buttons arranged between the hand wheels control respectively the grinding wheel motor, the hydraulic motor which supplies pressure fluid for the automatic traverse of the wheel slide and the headstock drive. A pedal is used to start the wheel slide in motion and enables the operator to control its speed when grinding flat broaches ; this arrangement leaves the operator's hands free to manipulate the hand wheels.

The headstock spindle is driven through belts by a 0·6 h.p., 1400 r.p.m. motor and pulley, designed to make available two spindle speeds of 250 r.p.m. and 500 r.p.m. The 7½in. diameter driving plate is notched and has an indexing plunger for two, three, four and six divisions. The tailstock has an adjustable loaded spindle barrel with a quick-withdrawal lever, which automatically locks the barrel in its rearmost position to facilitate the loading of heavy broaches.

The wheel head slide at the top of the vertical slide can be swivelled up to 45 deg. for grinding spiral or shear cut broaches. It is hydraulically actuated and the automatic traverse stroke,

Vehicle Body Sections Extended



Body Sections Nested

which is variable up to 4in, can be disposed in different positions to enable the wheel to grind centrally each side of the work table in the case of shear cut and ordinary flat broaches. The large hand wheel which actuates the vertical slide is fitted with a dial graduated in 0·001in.

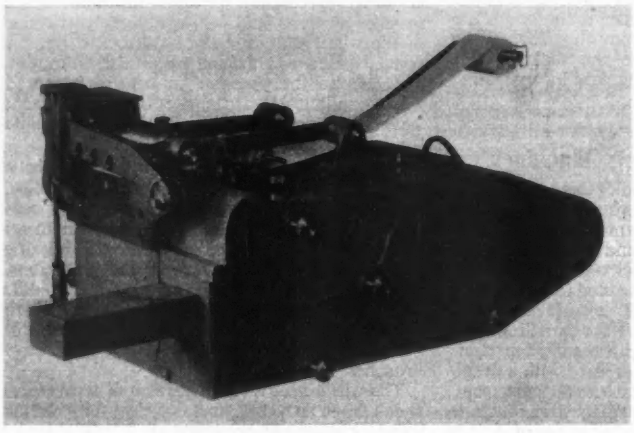
The main wheel spindle is directly driven by a 0·8 h.p. motor at 2840 r.p.m., and the complete spindle unit can be swivelled to any required angle. When it is required to grind very small broaches a high-speed spindle attachment can be fitted. This spindle is driven from a pulley mounted on the main spindle and runs at 8000 r.p.m. A profile wheel dresser which is provided is used with a template and incorporates its own slide movement to bring the diamond into contact with the wheel.

For grinding spiral broaches a leader bar having the same lead as the broach is used, and to the left-hand end of the machine base there is fitted a large bracket with a tee slot and guide-way which are used to carry the nut bracket. This nut bracket carries the tooling and index plate together with the leader nut. The leader bar engages with the rear end of the headstock spindle.

Automatic Strip Cutting-Off Machine

An automatic machine for cutting-off lengths of reeled or strip materials such as leather, rubber, plastic fibre, &c., is now being made in three models by E. W. Cowell, 7a, Sydney Road, Watford, Herts. Each model is designed to cut material up to 4in wide, one in any length up to 24in, the second in lengths of up to 12in and the third in lengths of up to 1½in, the respective cuts per hour made by the machines being 3300, 6600 and 20,000. A number of narrow strips can be fed through a machine at the same time, and the number of pieces cut naturally depends upon this number of strips.

One of the strip cutting machines is illustrated below. It consists of a substantial cabinet



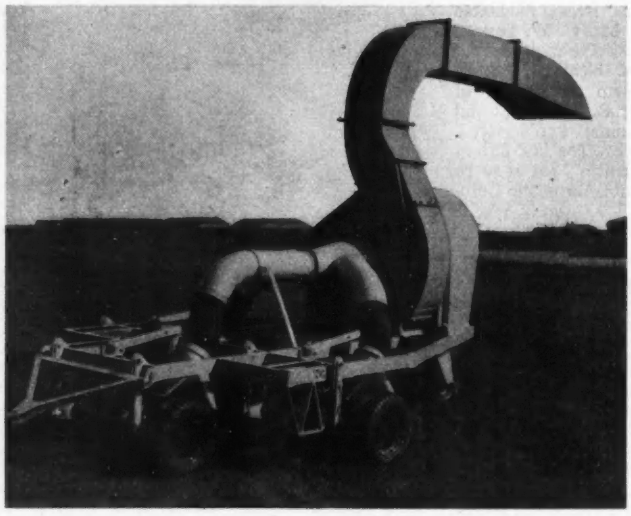
Strip Cutting Machine

within which the driving motor and gearing are totally enclosed. Material to be cut is fed through rollers which rotate intermittently and in one direction only, the amount of rotation controlling the length of strip cut off. The upper and lower feed rollers are geared together and are rotated by a sliding rack. This rack is coupled through a rod to a crank-pin which is adjustable along a slot in a disc driven by the motor. The position of the pin on the disc determines the length of rack movement and thus the amount the feed rollers turn between cutting strokes. At the end of each feed movement the rollers stop and the upper arm of the machine carrying a guillotine knife is actuated to shear off the length of material fed forward. Roller clutches incorporated in the feed gear assembly ensure correct rotation of the feed rolls without return movement.

The makers state that if required these machines can be fitted with a punch and die in place of the cutters for the production of such things as washers, small discs, &c.

Grass Mowing and Blowing Machine

A machine for cutting and collecting fairly short grass in one operation has been introduced by Air Control Installations, Ltd., Ruislip, Middlesex, and is shown in the accompanying illustration. It is known as the "Mowblow"



Grass Mowing and Blowing Machine

and consists of a set of ganged cylindrical mowers on which a blowing apparatus is assembled. The machine is claimed to be well suited for dealing with the grass on such places as airfields, golf courses and parks, and, of course, can equally well be used for the speedy cutting and collection of grass for drying.

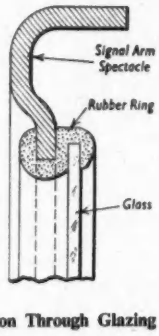
The mowers are of the "Ranger" five-cutter triple-gang design, manufactured by Thomas Green and Son, Ltd., Leeds. These mowers, which are driven from their land-wheels, together give a cut 7ft 2in wide, and for transport can readily be lifted clear of the ground by a hand lever and lifting chain. The principal part of the blowing apparatus is an open-bladed axial fan, manufactured by Air Control Installations, Ltd., which is fitted with a non-clog runner, and which is directly coupled to a 10 h.p. Petter air-cooled diesel engine. The sole function of the engine is to provide power for the fan, the average speed of which is 1400 r.p.m. This arrangement enables the fan to be started before the mowers begin cutting, and permits the fan to be run at its optimum speed quite independently of the speed of the land-wheels. The cut grass is thrown up into hoods which are fitted above the mower blades and then passes through flexible and rigid ducting to the fan inlet. It is then discharged through adjustable ducting into a following trailer which can be hitched to the machine. A recent addition to the "Mowblow"—which is not indicated in our illustration—is an adjustable deflector at the mouth of the discharge duct to control the angle at which the cut grass is emptied into the trailer.

The framework of the "Mowblow" is carried on six pneumatic-tyred land-wheels, the rear wheels, which are in pairs, having castor action. The machine and trailer can be towed by tractor or by a vehicle of the "Land Rover" class.

Signal Spectacle Glazing

An improved method of glazing for signal spectacle glasses which is being introduced on the London Midland Region of British Railways is designed to reduce the time and trouble involved when replacing broken glasses. At present the replacement of glasses fixed by putty and bifurcated rivets is a slow and laborious task involving the complete removal of age-hardened putty before a new glass can be inserted and secured. In the new method of glazing rings of extruded rubber section are used to hold the spectacle glasses in position in their frames. These rubber rings, in addition to speeding the work, provide a shock-absorbing seating and take up differential expansion between the glass and spectacle. The diagram below shows a cross section of a rubber glazing ring seating on the signal arm and the glass in position.

When replacing a broken spectacle glass the new glass is first fitted with its glazing ring. The rubber flange which is used to grip the spectacle is then pressed up clear of the aperture during insertion and held in this position by a metal former designed to pass through the aperture of the spectacle glass. The old glass is removed and the new glass in its ring is held



Section Through Glazing Ring

against the rear of the spectacle. The metal former, which is in position in the aperture, is then pulled off, passing through the aperture and releasing the rubber flange, which grips the spectacle firmly to hold the glass in position.

German Motorways

The number of motor vehicles in Western Germany is now about 3,270,000 (1952 figures), an increase of about 80 per cent from 1938. The overall mileage of motorways amounts to some 1320 miles, about 82 per cent of which are in good condition, while the rest must be either repaired or entirely restored, owing to damage which occurred during the war. As regards bridges, 391 structures (out of 514 destroyed during the war) are at present rebuilt, 376 of them being restored permanently. The reconstruction of all damaged bridges will require more than 150 million DM. (£13 million). The German authorities are studying an important programme of new highways for fast motor traffic. According to this scheme, about 1360 miles of new motorways will be constructed, of which 625 miles are to be for international traffic and 735 miles for inland communications. At present work is in progress on the construction of 53 miles of motorways, this modest part of the road programme already requiring a fairly substantial expenditure.

Industrial and Labour Notes

Double-Day Shift Working

For some time past, the National Joint Advisory Council has been considering the desirability of extending double-day shift working in industry as a practical means of contributing to increased production and lower production costs. It recognises that a widespread and general introduction of double-day shift working is neither practicable nor desirable, but considers that in certain circumstances the system could be of great value, as, for example, where capital costs are high in relation to labour costs and where better use could be made of existing plant and equipment.

The Minister of Labour has recently sent a memorandum on the matter to employers' and workers' organisations in selected industries in which it is thought there might be scope for extending double-day shift working. This memorandum—which is reprinted in the August issue of the *Ministry of Labour Gazette*—deals at some length with the effect of double-day shift working on labour costs, general overhead expenses, and capital charges. It comments that, in general, British industry is equipped for single-shift working, and that there are neither markets nor labour force available for the additional production which would come about from a change to double-shift working unless it was accompanied by a wholesale disuse of existing plants and premises. But, the memorandum adds, the introduction of double-shift working would be of great value where either capital costs are high in relation to labour costs, markets can be developed (assisted by lower production costs), and labour can be recruited to expand production on a two-shift basis ; or where it is necessary to increase output and the alternative would be to build an extension of the factory. In particular, the memorandum continues, the possible savings associated with the system should always be considered where there is the need to modernise and re-equip in order to maintain competitive efficiency and such re-equipment might be effected at half the cost for the same output on double-shift work. The adoption of shift working in such favourable circumstances, it is suggested, would lead to a gradual introduction of more shift work where its social inconveniences would be offset by the maximum economic gains.

T.U.C. Report on Public Ownership

As briefly recorded in these notes last week, the general council of the Trades Union Congress has issued a special report setting out its views on "public ownership" in industry. The document is in the nature of an interim report arising from a resolution, passed at last year's Congress, which called upon the general council "to formulate proposals for the extension of social ownership to other industries and services, particularly those now subject to monopoly control." The resolution urged also that general proposals should be formulated for the "democratisation of the nationalised industries and services calculated to make possible the ultimate realisation of full industrial democracy."

The introduction to the present report states that public ownership is inevitably an acute political issue and the fact that there have been initial shortcomings in the nationalised industries has provided material for propaganda which was not there in 1944. It would not be true to-day to say, the report continues, "that public opinion is strongly prepared for the transfer of further industries to public ownership." Any proposals for the extension of this form of public control, therefore, must grow logically and demonstrably out of the experience of nationalisation already gained, and out of the present needs of the community. Such proposals, the T.U.C. general council asserts, must not only be sound in themselves ; they must be capable of attracting wide public support. The report then proceeds to a fairly detailed review of the existing nationalised industries and to a survey of the nation's economic requirements. It concludes with a section entitled "Criteria for the Extension of Public Ownership," which sets out, among other matters, trade union proposals concerning the engineering, shipbuilding and aircraft industries. These proposals, for the most part, have been discussed in the "Plan for Engineering," formulated by the Confederation of Shipbuilding and Engineering Unions.

In some general conclusions which are given in the report, the T.U.C. says that it is for the most part impossible, at the present stage, to say which industries should become publicly owned, as that can only be decided after further thorough investigation of the facts, and "in the light of our changing economic fortunes." The interim report, it is stated, has been able to do little more than map out roughly "the route for what will necessarily be a long journey."

Changes in Wage Rates

The Ministry of Labour has reported that changes in wage rates which came into operation in the United Kingdom during July resulted in an aggregate increase estimated at approximately £207,000 in the weekly full-time wages of about 1,134,000 workpeople, and in a decrease aggregating about £6000 for 189,000 workpeople. Among those receiving increases were manual workers in electricity supply undertakings, and workers in the brick-making industry in England and Wales. The decreases affected mainly those employed in the iron and steel industry, ironstone mines and limestone quarries in certain districts. They resulted from sliding scale arrangements based on the index of retail prices. The Ministry says that in the first seven months of this year changes in wage rates led to an aggregate increase of £1,326,900 in the weekly full-time wages of about 4,956,500 workpeople. In the comparable period of last year there was a net increase of £2,098,000 in the weekly full-time wages of 5,131,000 workpeople. At the end of July, the index of rates of wages (June 30, 1947=100) stood at 136 for all workers, having been 135 since the end of February.

Industrial Production

The Central Statistical Office of the Treasury has stated that the index number of industrial production (1948=100) has been estimated provisionally at 119 for all industries in the month of June, compared with 123 in May. Figures for the corresponding months last year were 112 in June and 117 in May.

The index for June, 1952, and for May, 1953, was affected by the Whitsun holiday, and for June, 1953, by the holiday in honour of the Coronation. Taking the industrial groups separately, the index numbers for the manufacturing industries were 126 and 121 in May and June respectively this year, compared with 120 and 131 in 1952. The Treasury says that, from the information it has so far received, the index for all industries in July this year is likely to be 112 or 113, owing, of course, to the incidence of annual holidays.

Steel for Shipbuilding

In a statement which accompanies the annual report and accounts of Richardsons, Westgarth and Co., Ltd., the chairman, Mr. O. J. Philipson, comments on the continuing shortage of steel plates and the effect of that shortage on the British shipbuilding industry. He says that whilst, in some cases, it has become easier to acquire necessary materials, the supply of steel boiler plates has worsened rather than improved. Ships have already been delayed on this account, and of fifteen vessels now in the water awaiting machinery installations, some will inevitably be delayed through lack of heavy section steel plates for their boilers.

Mr. Philipson asserts that the production of these plates is out of step with the production of other descriptions of steel and unless the sequence of supplies can be re-established and the bottle-neck removed, serious dislocation of production programmes will continue. Foreign boiler plates have been and are being purchased, but as yet the supply difficulty, which is a national question, remains. The statement then comments on the resurgence of shipbuilding in Italy, Germany and Japan. From official statistics, Mr. Philipson says, it is clear that activity in foreign yards has been increasing as the proportion of world tonnage being constructed in British yards, which was some 50 per cent for some time after the war, declined to 40 per cent and is now about 35 per cent. The amount of new tonnage placed on order in Britain has declined from 482,000 tons in the first quarter of 1952 to 170,000 tons in the first quarter of this year. Mr. Philipson observes that there has been some cancellation of ships on order and that prominent shipowners have declared their intention of deferring arrangements to place more ships on order and even of cancelling outstanding contracts, if costs increase. Whether or no, Mr. Philipson says, the Government is correct in its stated views that the falling off in orders for ships and recent cancellations are no cause for alarm, they are trends which must be viewed with deep concern.

Industrial Disputes

During July, there were eighty stoppages of work through industrial disputes in the United Kingdom which were reported to the Ministry of Labour. In addition, there were still in progress seventeen stoppages which had begun prior to July. In these ninety-seven stoppages, about 32,000 working days were lost in July by 15,100 workpeople. That was a considerable improvement upon the situation in July last year, when, as a result of stoppages of work through disputes, about 272,000 working days were lost by 41,200 people. In the first seven months of this year there were 929 stoppages reported to the Ministry, involving 155,500 workpeople and causing a loss of 679,000 working days. In the corresponding period of last year, 1021 stoppages occurred, resulting in an aggregate loss of 1,169,000 days by 231,200 workpeople.

Dispute in the Electrical Contracting Industry

In our last issue, on page 286, there was a brief reference to the strikes which had started in the electrical contracting industry in various parts of the country. These stoppages were recognised by the Electrical Trades Union, and were stated to be a protest against the refusal of the National Federated Electrical Association to continue negotiation of a wage claim. During last week officials of the Ministry of Labour discussed the situation with both sides of the industry, and as a result of those conversations the Electrical Trades Union agreed to call off the strikes so that the National Joint Industrial Council for the electrical contracting industry could meet to consider the position.

A meeting of that council was held last Monday, but failed to reach agreement. Immediately, the Electrical Trades Union announced that strike action would be resumed, and on Tuesday electrical work on several building projects again ceased. Spokesmen for the National Federated Electrical Association had intimated at the meeting of the Joint Industrial Council that the Association's affiliated firms must be consulted about the union's demands, but that course was not acceptable to the union representatives. The Association then told the Ministry of Labour that it would formally report the dispute for arbitration if that was considered to be the best course.

As we go to press, there are indications that the strikes are spreading, and it was being suggested by the union that, by Monday next, the number of men involved would reach 5000. The chief industrial commissioner of the Ministry of Labour has had further individual talks with representatives of the union and the employers' association, but there seems little likelihood of the negotiations being resumed this week.

Notes and Memoranda

Rail and Road

SEA DEFENCE SCHEME IN NORTH WALES.—The London Midland Region of British Railways says that work is now beginning on strengthening the mile-long sea wall at Llanfairfechan, which protects the London Midland main line on the Irish Mail route. Dwarf concrete walls, bedded in the clay and shingle to a depth of from 4ft to 5ft, forming a series of rectangles 40ft long by 12ft wide, are to be introduced. These rectangles are filled in with ordinary stone pitching, but without the smooth level topped face of the previous methods. Large block quarry stones will be used. On the North Wales coast between Holywell embankment and Llanfairfechan regular sea coast maintenance gangs are employed throughout the year and a tide watching scheme is immediately brought into operation when the predicted height of tides or high winds make precautions necessary.

SUNDERLAND STATION IMPROVEMENTS.—The North-Eastern Region of British Railways states that Sunderland Station is being modernised at a cost of £50,000. Work which has already been completed includes the remodelling of the concourse and buildings at the south end and the removal of the overall roof and erection of umbrella roofing to the platforms. Remodelling of the concourse and buildings at the north end is now being developed. The platforms and railway lines of Sunderland Station lie in a cutting running north and south and bounded by retaining walls on the east and west sides. Until recently platforms and tracks were covered by a roof of overall design carried on semicircular arch ribs spanning between retaining walls, and erected in 1878. This roof suffered bomb damage in 1943, when a portion of the overall roof was replaced by low-level platform "umbrella" roofs. Access to the platform is from concourses at street level at the north and south ends. The interior accommodation of the southern concourse has been entirely replanned.

Air and Water

FLEET COMMODORE.—The Pacific Steam Navigation Company announces that Captain John Whitehouse, who has been in command of the "Reina del Pacifico" since 1947, has been appointed commodore master of the fleet.

FLOOD WARNING SYSTEM.—The Minister of Housing and Local Government has announced that arrangements are being made to introduce a system of flood warnings, as from September 15th. The system is based on recommendations made in the interim report of the departmental committee on coastal flooding.

CONFERENCE ON NORTH SEA FLOODS.—A conference on the North Sea floods is being arranged by the Institution of Civil Engineers, to take place in London on Wednesday and Thursday, December 16th and 17th. Twelve papers are to be presented. Those to be discussed on the first day of the conference are :—"A General Survey of the Damage and the Action Taken," by Mr. J. V. Spalding ; "Storm Surges on the East Coast," by Commander W. I. Farquharson ; "Some Meteorological Aspects," by Mr. S. P. Peters ; "Soil Mechanics of Some Failures in the Sea Defence Banks of Essex and Kent," by Mr. L. F. Cooling ; "Design o Sea Defence Works in Relation to Height of Tide and Degree of Exposure," by Mr. C. H. Dobbie ; and "The Incidence of Storm Surges as a Factor in the Design of Coast Protection Works," by Mr. J. Duvivier. On the second day of the conference, December 17th, the papers to be presented are :—"Sea Defence Works on a Sandy Eroding Coast with Scanty Littoral Drift," by Mr. S. W. Mobbs ; "Damage to the Kent Coastline, and Restoration Works," by Mr. Cubley Crowther ; "Damage to the Essex Coastline, and Restoration Works," by Mr. E. L. Snell ; "Sea Defences in the Wash and Estuary of the Great Ouse," by Mr. W. E. Doran ; "Flood Damage in Norfolk and Suffolk, and Restoration Works," by Mr. K. E. Cotton ; and "Damage and Remedial Operations on the Lincolnshire Coast," by Mr. F. H. Tomes.

Miscellanea

ULTRASONIC EQUIPMENT FOR DETECTING FLAWS IN RAILS.—In our issue of July 3rd last, we described the use of the "Audigage" ultrasonic flaw detector now being used by London Transport for detecting flaws in rails. We are informed that this equipment was supplied to London Transport by Equipment and Engineering, Ltd., 2 and 3, Norfolk Street, London, W.C.2.

INSTITUTION OF MECHANICAL ENGINEERS.—The annual dinner of the Institution of Mechanical Engineers will be held at the Dorchester Hotel, Park Lane, London, W.1, on Thursday, October 15th, at 7 for 7.30 p.m. On the following evening, October 16th, Mr. A. Roebuck will deliver his presidential address, entitled "The Craftsman," at a general meeting to be held at 5.30 p.m. at the Institution's headquarters at Storey's Gate, Westminster, S.W.1.

LECTURES ON WELDED STRUCTURES AND PRESTRESSED CONCRETE.—A special course of lectures on the Design of Welded Structures will be given at the London County Council's Brixton School of Building on Monday evenings, commencing on Monday, October 5, 1953. Tutorial study of design calculations is included in the course, which also deals with specifications for welded work. A course of lectures on prestressed concrete design and construction is also to be given at the Brixton School of Building on Wednesday evenings, commencing on October 7, 1953. The course will include a general survey of the subject and detailed study of the analysis and design of typical sections. Attention will also be given to the design of end blocks, anchorages, continuous structures and special constructions such as poles, piles and tanks. The course will end just before Easter, 1954. Both the courses are intended for those who have reached graduate standard in theory of structures and, in the second case, for those who are experienced in reinforced concrete design. Further particulars may be obtained from the Secretary, L.C.C. Brixton School of Building, Ferndale Road, S.W.4.

OIL SEARCH.—At Plungar, some 23 miles south-east of the Eakring area, where the company has producing oil fields, the D'Arcy Exploration Company, the prospecting subsidiary of the Anglo-Iranian Oil Company, Ltd., has begun to drill an exploratory well. This well is planned to be drilled to 3500ft. A second test well at West Drayton, near Tuxford, has reached a depth of 2500ft and work on the bore-hole at Screveton, near Newark, has been stopped after drilling to a depth of 3621ft without finding oil.

COAL BOARD'S SUMMER SCHOOL.—The seventh summer school to be arranged by the National Coal Board opens to-morrow, September 5th, at Oxford University. It will continue for a week, during which about 500 of the Coal Board's employees will be in residence in various colleges. Sir Hubert Houldsworth, chairman of the Board, will give the opening address to the school tomorrow evening, and the closing talk on September 12th will be given by Sir Andrew Bryan, a member of the Board and formerly H.M. Chief Inspector of Mines.

BRISTOL ENGINEERING MANUFACTURERS' ASSOCIATION.—The Bristol Engineering Manufacturers' Association has recently published a directory setting out the names and addresses of its member firms and, in a classified section, the nature of their products. Information as to the origin and objects of the Association is given in the directory, as well as a series of illustrations showing some of the activities and products of the engineering industry in and around Bristol. The secretary of the Bristol Engineering Manufacturers' Association is Mr. C. O. Worth, 16, St. Stephen Street, Bristol.

A DIE GRINDER KIT.—A new die grinder kit has been introduced by Wolf Electric Tools, Ltd., for use in toolrooms, machine shops and maintenance departments. The driving unit has a capacity for grinding wheels up to 1¼in diameter by ¼in and has a speed (running light) of 16,000 r.p.m. The input on full load is 270W and the net weight of the unit is 5 lb. The complete kit comprises the high-speed grinder with its cable, a spare set of carbon brushes, a selected set of mounted points, grinding wheels and felt bobs and arbors, all of which are completely housed in a steel carrying case.

THE NEWCOMEN SOCIETY.—On Friday, September 25th, members of the Newcomen Society are to visit Haddiscoe and Lound, near Lowestoft, to see two designs of grasshopper pumping engines. The new session of the society begins on Wednesday, October 14th, when papers will be presented by Mr. E. A. Forward on "Report on Railways in England in 1826-27 by Carl von Oeynhausen and Heinrich von Dechen," and by Mr. H. H. Hansa on "The First Watt Type Engine in Denmark." The annual general meeting will be held on Wednesday, November 11th, on which occasion Mr. J. Foster Petree will deliver his presidential address.

STEELMAKING COURSE FOR BOYS.—At the invitation of the United Steel Companies, Ltd., thirty-five boys from sixteen public schools are spending this week in Sheffield as the guests of the company in order to take part in a short course on iron and steel making. The aim of the course is to give an insight into the manufacture of iron and steel and the manipulation of steel, the manufacturing uses of high-quality steels, some characteristic problems in research, and the opportunities available for careers with a large steel company. It is hoped that the course will benefit those who attend and will assist them in deciding the sort of career they would like to follow when the time comes for the boys to make their choice.

EXHIBITION OF HISTORIC BOOKS.—The Science Museum announces that the closing date for its exhibition of historic books on machines has been deferred to October 11th, so that more people may have the opportunity of seeing a valuable collection of books which show how machines were developed in the period from about 200 B.C. to about A.D. 1800. The books are accompanied by many interesting photographic reproductions of the machines portrayed in their pages. A list of these reproductions, with prices, can be obtained (free) from the Science Museum, South Kensington, London, S.W.7. A catalogue of the exhibition containing biographical, historical and technical information can be purchased from the Science Museum or from H.M. Stationery Office, price 1s. 8d.

MOLYBDENUM.—Restrictions on the use of molybdenum in case hardening and constructional steels in member countries of the Organisation for European Economic Co-operation have been suspended by a decision of the council of the Organisation. These restrictions were imposed in May, 1952, as a result of shortages of molybdenum and nickel in world markets. The new decision does not apply to nickel, for it is stated that the present improvement in the supply situation is not sufficient to justify the abolition of the restrictions in force. The council has instructed its iron and steel committee to follow closely the supply position for molybdenum and to make appropriate proposals for the final repeal of restrictions or for their reimposition, should the supply position make it necessary.

AN IMPROVED SHEET MATERIAL FOR HIGH-TEMPERATURE USES.—For many years the high-strength, high-temperature alloy, developed under the name of "Nimonic 75," has been widely used in sheet form for the combustion chamber linings in many British gas turbines. In this component the chief requirements of the metal are strength to resist distortion and cracking through the stresses arising from thermal expansion, plus high resistance to scaling. "Nimonic 75" fulfils these needs to an adequate degree and, in addition, readily lends itself to normal fabricating, including argon arc and resistance welding. For some time work has been going on to develop a material which would have the characteristic properties of "Nimonic 75," but, at the same time, would have a much higher heat conductivity in order to dissipate the heat of the combustion in the chamber more quickly and secure a much more even temperature distribution in the chamber. Henry Wiggin and Co., Ltd., now announces the introduction of composite metal sheets having "Nimonic 75" on both sides of a copper base. This metal sandwich, known as "Nimoply 75," is produced by rolling copper between sheets of "Nimonic 75," resulting in a clad sheet having many potential uses, not only in gas turbine construction, but also in other fields of high-temperature engineering.

Personal and Business

MR. DONALD H. HASLAM has been appointed legal adviser to the National Coal Board.

GROUP CAPTAIN E. C. LEWIS has been appointed a director of Hick, Hargreaves and Co., Ltd., Bolton.

THE FIRE PROTECTION ASSOCIATION states that its address is now 15, Queen Victoria Street, London, E.C.4 (telephone, Central 4642).

THE GENERAL ELECTRIC COMPANY, Ltd., announces the retirement of Mr. J. W. Stevens from the board of the Express Lift Company, Ltd., Northampton.

CROMPTON PARKINSON, Ltd., states that Mr. F. Foster has been appointed manager and Mr. R. W. Taylor sales manager (home) of its stud welding organisation.

THE HYMATIC ENGINEERING COMPANY, Ltd., Redditch, Worcs, announces the appointment of Mr. K. R. Harris as technical representative in the North of England.

THE FAIRMILE CONSTRUCTION COMPANY, Ltd., Cobham, has acquired the Berwick shipyard at Berwick-on-Tweed, and has also taken a major holding in a yard at Hayling Island, Hants.

MR. J. SAVAGE is to succeed Mr. M. W. Thring, on October 1st, as head of the British Iron and Steel Research Association's physics department. He joined the staff of the department in 1947.

A. E. L. MASH AND ASSOCIATES announce their removal to new offices at Avenue House, 25, Shaftesbury Avenue, London, W.1 (telephone, Gerrard 3362 ; telegrams, "Informash, Lesquare, London.").

MR. G. H. TOOP, A.M.I.Mech.E., has left his position as a field development engineer with George Kent, Ltd., Luton, to join George Kent (S.A.) (Pty.), Ltd., Johannesburg, as development engineer specialising in automatic process control.

MR. JOHN HARRISON, formerly area production manager in the South-Western Division of the National Coal Board, has been appointed managing director of Cyprus Copco, in Nicosia, Cyprus, a company established by the Atlas Diesel organisation.

FERRYBRIDGE INDUSTRIES, Ltd., states that a London office for its Pollard bearing and Philidas self-locking nut divisions has been opened at 6, St. James's Place, S.W.1 (telephone, Hyde Park 9248). Mr. W. F. Clay, southern counties area manager, has charge of the office and Mr. T. S. Nethersole will attend to technical and sales matters concerned with the Philidas division.

Contracts

THE BURMESE PURCHASING COMMISSION has placed an order with Johnston Brothers (Contractors), Ltd., for five "Superspray" pressure distributors, each of which will be mounted on an A.E.C. "Mammoth" six-wheeled chassis. It is anticipated that all the units will be complete for despatch before the end of this year. The value of the contract is approximately £25,000.

THE FRASER AND CHALMERS ENGINEERING WORKS of the General Electric Company, Ltd., has received a contract from the National Coal Board, West Midlands Division, No. 2 (Cannock Chase) Area, for two electric winder equipments for the new sinkings at Lea Hall Colliery. The equipment will include a single-drum winder, designed for an output of 280 tons per hour, winding from a depth of 1412ft. This winder will use two-deck cages, with one mine car of 3 tons capacity on each deck, giving a net load per wind of 6 tons of coal. The drum will be 16ft diameter by 7ft wide and will be driven through single reduction gears by a single a.c. motor. The maximum rope speed will be 1975ft per minute. In addition, a double-drum winder, of which one drum is clutched, and which has been designed for an output of 250 tons per hour, will wind from depths of 1032ft, 1420ft and 1732ft, using similar cages to the single-drum winder. The drums will be 16ft diameter by 3ft 6in wide, driven through single reduction gears by a single a.c. motor. The maximum rope speed will be 1975ft per minute. Both equipments will be arranged for dynamic braking, and will be driven by G.E.C. 2100 h.p., 3·3kV induction motors running at 375 r.p.m. The motors and control gear will be built at the Witton Engineering Works of the G.E.C.

British Patent Specifications

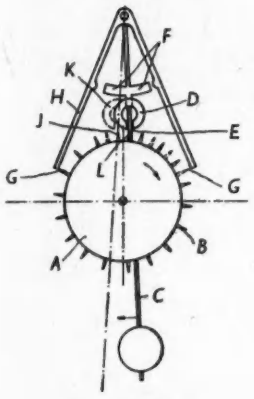
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

ELECTRICAL ENGINEERING

694,574. August 2, 1950.—TIME MECHANISMS, Siemens-Schuckertwerke Aktiengesellschaft, Berlin-Siemensstadt, Berlin, and Sieboldstrasse 5, Erlangen, Bayern, Germany.

The invention is for improvements in or relating to time mechanisms having an escapement periodically controlled by a movement regulator; for example, a pendulum or balance, drives the movement regulator through the medium of the escapement. Referring to the drawing a time mechanism drives a toothed disc A of magnetic material having teeth *B*. The teeth of the disc act as the escapement and form the operative parts of a permanent magnetic mechanism. Rigidly mounted on a pendulum *C* in proximity to the teeth *B* is a slotted annular permanent magnet *D*, in which a slot *E* is directed towards the uppermost teeth *B* of the toothed disc *A*. The pendulum is

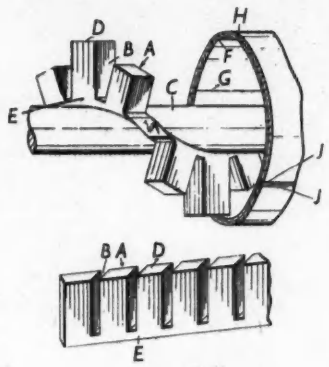


No. 694,574

operable, through the medium of stops *F*, to move alternately each claw *G* of an escapement lever *H* out of the range of the teeth, so that the disc, driven in the direction of the arrow, is permitted to move forward in steps equivalent to one-half of a tooth pitch. In the position shown, the pendulum *C* swings from the right-hand end position in the direction of the arrow. As the gap *E* in the magnet *D* moves towards the tooth *J*, the magnet *D* receives from the magnetic force between the two parts an accelerating impulse of a magnitude sufficient to overcome the frictional and switching work to be performed by the pendulum. As soon as the pendulum reaches the end position shown in chain lines, in which the magnet occupies the position *K*, the left-hand claw *G* disengages the left-hand stop and the disc *A* passes into the position shown with the teeth in chain lines. In the return swinging movement which follows, the gap in the magnet approaches the tooth *L*, which causes the pendulum *C* to receive a further driving impulse, and so on. Thus the magnetic energy storing means consisting of the magnet *D* and the teeth *B* is charged or loaded as a result of the movement of the face of a tooth away from the magnet and is discharged or unloaded due to the fact that the magnet connected to the pendulum moves nearer to the tooth. A certain quantity of energy is thereby continuously stored up in the magnetic energy storing means and is discharged therefrom to the pendulum which, in this case, forms the movement regulator. The invention has the advantage that the escapement members which normally require very great precision, can be made much coarser and simpler, since they are not required to transmit the driving energy to the movement regulator. However, the movement regulator which otherwise generally causes breakdowns due to the sensitiveness of its mounting may be mounted in a much less sensitive manner.—*July* 22, 1953.

694,986. March 20, 1951.—ELECTRIC CABLES, British Insulated Callender's Cables, Ltd., Norfolk House, Norfolk Street, London, W.C.2. (*Inventor: William Gerard Worrall.*)

The invention is concerned with air-space-insulated electric cables in which a central conductor is enclosed within a coaxial outer member and spaced from it by an insulating strip applied helically in an open winding about the conductor. The strip is made of flexible, tough insulating material such as polystyrol, polyvinyl chloride, polyethylene and compositions of these plastic materials. As will be seen from the drawings, the strip *A* is of rectangular cross section and is slotted at regular intervals along its length, the slots *B* extending from one edge of the strip almost, but not quite, to the opposite edge and being oblique to the two major surfaces of the strip. The angle of obliquity is determined by the angle of lay with which the unslotted edge of the strip is to be applied to the central conductor *C* of the cable. As will be seen from the upper view, the angle of lay at the surface of the conductor is 45 deg. Accordingly, the angle of obliquity is approximately 45 deg., as is shown in the lower view. The strip *A* is lapped helically on the central conductor with a direction of lay such as to cause the slots to run parallel with the axis of the conductor. This causes the slots to open



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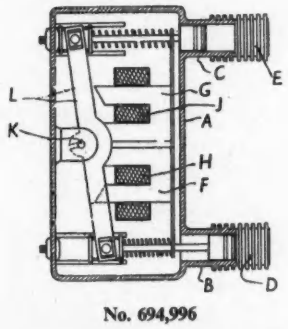
out and assume a wedge shape as shown. The intervening parts *D* of the strip assume the form of prisms projecting radially outward from the outer surface of the continuous portion *E* of the strip and their outer end faces, or, at least the edges that run parallel with the cable axis, engage the internal surface of the coaxial outer member and centralise the conductor. The coaxial outer member may be a two-ply structure consisting of an inner layer *F* of which the edges make joint at *G*, and an outer layer *H* of which the edges *J* are circumferentially displaced relative to the joint *H*. One or both layers may be of metal strip transversely bent to form a cylinder. By applying the strip *A* with the slots *B* extending parallel with the conductor, the strip is subjected to less stressing than it would be were the slots disposed at an angle to the wire—for instance, normal to the initial plane of the strip.—*July* 29, 1953.

694,996. June 21, 1951.—ELECTROMAGNETIC GAS COMPRESSORS, Alejandro Poliansky, 767, Sarmiento, Buenos Aires, Argentina.

The invention refers to an electromagnetic gas compressor, in which the linear movement of at least one armature attracted by electromagnetic force is directly used for operating the piston of a compressor cylinder. Referring to the drawings, the compressor comprises a casing *A* and the cylinders *B* and *C* of the two compressor heads, the pressure chambers *D* and E of the compressor heads being firmly secured to the free open ends of the cylinders. Both the cylinder and the pressure chamber of each com-



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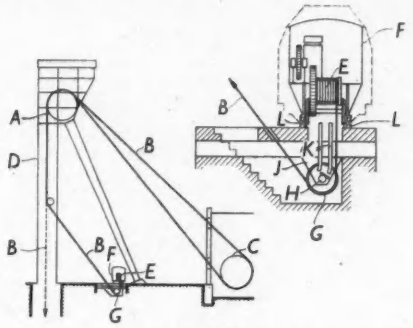
pressor head are provided with cooling ribs. The wall of the pressure chamber adjacent the open end of the compressor cylinder has a gas inlet opening, which is controlled by a valve under the pressure of a coil spring, the valve being guided by means of its rod. The compressor cylinder has a composite piston consisting of a hollow cylindrical compressing piston and a solid operating member arranged within it. The electromagnetic mechanism for operating the compressor comprises two electromagnets formed by the cores *F* and *G* and the magnetic coils *H* and *J*. As soon as one or another of these coils is energised their cores attract their respective armatures constituted in this case by the arms of a lever pivoted at *K*. If desired, the armatures may be formed by bodies secured to the lever arms. The co-operating surfaces of the armatures and of the cores are conveniently chamfered at *L* for obtaining a smaller gap between the surfaces and a greater effect of electromagnetic attraction. Modified designs and an automatic switch for alternately energising the two electromagnets in the correct moments are also described in the specification.—*July* 29, 1953.

MINING ENGINEERING

694,658. November 24, 1950.—RAISING OR LOWERING HEAVY LOADS IN PITS, Demag Aktiengesellschaft, 64, Werthauser Strasse (22*a*), Duisburg, Germany. (*Inventor: Sophus Brauer.*)

The invention relates to apparatus for mounting winding ropes or cables on to the cable pulleys of pithead gears. Referring to the drawings, the cable



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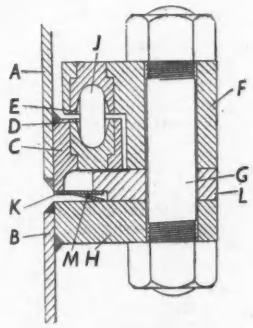
pulley *A* for the conveyor cable *B*, which is operated by the driving pulley *C*, is mounted in the pithead gear *D*. The winch mechanism *E*, which is required for mounting the winding cable *B*, is provided on a truck frame *F*, and stands above a diverting pulley *G* anchored to the ground. The winding cable to be mounted runs first from the winch mechanism *E* vertically downward, and then around the pulley *G* to the cable pulley *B*. The pulley *G* is mounted on the shaft *H*, which can be disconnected from the brackets. *J* and *K* are guide rails by means of which, when not in use, the pulley *G*, together with the shaft *H*, may be lifted upward so as to be accommodated in the vehicle or frame *F*. *L* denotes the supporting trestles which, with the vehicle in operation, are pushed underneath the truck frame *F* so as to ease the load exerted by the pull of the cable *B*. Various modified arrangements are also described and illustrated in the specification.—*July* 22, 1953.

TUBE AND PIPE COUPLINGS

694,922. August 2, 1951.—FLEXIBLE PIPE JOINTS, The Parsons and Marine Engineering Turbine Research and Development Association, of Pametrada Research Station, Wallsend-on-Tyne, Northumberland. (*Inventor: Henry George Yates.*)

The drawing shows the invention applied to pipes conveying gas under pressure. One end of one of two pipe lengths *A* and *B* is furnished with a rigid flange *C* furnished on one face with a set of cup-shaped sockets *D* in axial register with a further set of similar sockets *E* in a preferably split clamping ring *F*. The clamping ring, which embraces the first pipe length *A*, is secured by a set of axial bolts *G* to a flange *H* rigid on the adjacent end of the pipe *B*. Interposed



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between each pair of registering sockets *D* and *E* is a pin *J* having rounded ends, the pins being in compression under the action of hydraulic pressure in the pipe. A sealing ring *K* is fitted in a gap between the ends of the pipes to prevent fluid leakage, this ring being annular in form and designed to bear in

the region of its inner periphery against a suitable surface at the end of the pipe *A* and to bear in the region of its outer periphery against a suitable surface on a seat ring *L* between the clamping ring *F* and the flange *H*. The fluid pressure in the pipes holds the sealing ring in close contact with these surfaces. A spring member is also provided to keep the sealing ring in position in the absence of fluid pressure. This conveniently comprises a conical ring *M* of thin metal, perforated at intervals, which is slightly compressed when the pipe joint is assembled. The arrangement is such that the effectiveness of the seal increases in proportion to the pressure against which it is required to seal. Alternative arrangements are also shown in the specification.—*July* 29, 1953.

AERONAUTICAL ENGINEERING

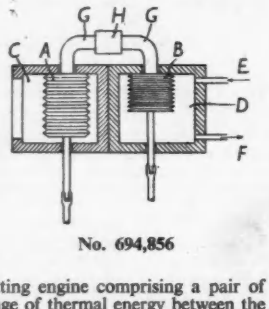
694,783. May 3, 1950.—ICE WARNING INDICATORS, Maldon Cavendish Harley, of Paxton Hill, St. Neots, Huntingdonshire. (*Inventor: Frank Brooke Smith.*)

The invention consists of a warning device for indicating when there is a liability of ice forming on the forward edges of an aircraft wing. An electrical conductor element having a substantial temperature/resistance coefficient connected in series with a hygroscopic unit comprising a mass of absorbent material is provided. The two units are assembled so as to be exposed to the air flow, the arrangement being such that when there is free moisture present in the air it is caught in the channel and directed to the absorbent material. The device further comprises a relay, a magnetic indicator or indicating lamp connected in the circuit of the two elements. In operation, in the event of the temperature of the conductor falling to a few degrees above freezing point and, at the same time, the absorbent material being wetted to a predetermined extent, sufficient current will flow to operate the indicator. The conductor elements may be substituted by a switch which operates only below a predetermined temperature and the conductor and hygroscopic elements may be mounted as one assembly or assembled as separate units.—*July* 29, 1953.

AIR ENGINES

694,856. December 16, 1949.—REVERSED HOT GAS ENGINES WORKING AS REFRIGERATING UNITS, N. V. Philips' Gloeilampenfabrieken, Emmasingel 29, Eindhoven, Holland.

The invention relates to hot gas engines, or refrigerating engines or heat pumps operating on the reversed hot gas engine principle, comprising two working spaces, the volumes of which are varied with a relative phase difference. The drawing shows



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a refrigerating engine comprising a pair of bellows, the exchange of thermal energy between the working medium of the engine and the external means for the supply and dissipation of thermal energy from the working medium being effected through the walls of the bellows. The heated bellows *A* and the cooled bellows *B* are connected through the rods shown to a common crankshaft with cranks having a phase difference of 90 deg. The bellows have a double function, first, as working spaces of variable volume, and secondly as a wall through which thermal energy is supplied to or withdrawn from the working medium taking part in the thermodynamic cycle. This arrangement affords the advantage that the working medium is expanded and compressed substantially isothermally. The engine shown is intended for use as a refrigerator operating according to the reversed hot gas engine principle. Space *C* about the bellows *A* serves as the refrigerator space, so that thermal energy is supplied from the space *C* through the wall of the bellows *A* to the working medium. Thermal energy is withdrawn through the wall of *B* from the working medium to space *D* about the bellows by means of a cooling medium which flows into space *D* at *E* and leaves this space at *F*. The two working spaces in the bellows *A* and *B* communicate with each other through a duct *G* comprising a regenerator *H*. Since the thermal energy is supplied and withdrawn through the walls of the bellows, the heater and the cooler are dispensed with. In the above case space *D* is the so-called "hot" space at 20 deg. Cent. and space *C* is the "cold" space at −60 deg. Cent. If the arrangement is intended to operate as a hot gas engine the transfer of thermal energy is effected in the same general way, but space *C* becomes the "hot" space at, for example, 600 deg. Cent. and space *D* the "cold" space at, for example, 80 deg. Cent.—*July* 29, 1953.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

RUBBER-INSULATED CABLES AND FLEXIBLE CORDS FOR ELECTRIC POWER AND LIGHTING

No. 7 : 1953. Price 10s. This edition supersedes B.S. 7 : 1946 in regard to its subject. It incorporates many of the requirements of Government Department Electrical Specifications Nos. 1, 8, 9 and 10, which it is understood are being withdrawn. The supplement to the 1946 edition, which permitted polyvinyl chloride (P.V.C.) as an alternative to vulcanised rubber, is superseded by the issue of B.S. 2004 : 1953. The main changes are the reduction of insulation thickness and the introduction of quality clauses. The reduction in insulation thickness has been found possible in view of many years' satisfactory service experience, together with the progress made in rubber technology, and it is considered that this change will not affect the practical performance of the cable. The quality clauses introduced by the 1949 amendment No. 3 to B.S. 7 are included as well as chemical and physical tests based on B.S. 903, "Methods of Testing Vulcanised Rubber," which have been extended to apply to rubber sheath. Other new matters are the specification of the composition of various kinds of tough rubber sheath, requirements for the aluminium sheath, the inclusion of hard drawn copper conductors for house service overhead system (H.S.O.S.) cables, and the adoption of 20 deg. Cent. as the standard reference temperature.

POLYVINYL CHLORIDE INSULATED CABLES AND FLEXIBLE CORDS FOR ELECTRIC POWER AND LIGHTING

No. 2004 : 1953. Price 6s. This standard replaces the supplement to B.S. 7 : 1946, which permitted the use of P.V.C. as an alternative to vulcanised rubber for insulation or sheath, or both, for flexible cords and for 250V and 660V cables up to 0·06 square inch cross section. It deals only, however, with P.V.C. insulated cables and flexible cords (sheathed or unsheathed) for working voltages up to 250V. The insulation thicknesses are similar to those for corresponding rubber-insulated cables and flexible cords specified in B.S. 7 : 1953, except that the insulation thickness for the unsheathed single-core P.V.C. cable is greater than for its rubber counterpart. Similarly, the physical tests for the sheath and insulation are based on the methods specified in B.S. 7 : 1953 The standard also includes a fire-resisting test similar to that specified in B.S. 883.

DIMENSIONS OF DIAMOND TRUING TOOLS

No. 2002 : 1953. Price 2s. 6d.—This standard has been prepared to assist in rationalising the present very large number of truing tool sizes now in use in industry. It specifies dimensions and tolerances for diamond truing tools for grinding wheels, of straight, headed and taper shanks, and specifies weight ranges of single diamonds to be used with each type. It gives guidance also, in an appendix, to users as to the correct use of these tools.

Launches and Trial Trips

BAWEAN, cargo liner; built by the Netherlands Dock and Shipbuilding Company for the Nederland N.V. Stoomvaart Mij; length between perpendiculars 140·21m, breadth moulded 19·66m, depth moulded to upper deck 12·27m, draught 8·576m, displacement 16,600 tons, deadweight 10,925 tons, speed 16 knots; five cargo holds, derrick complement includes one 40 tons and one 65 tons capacity; M.A.N single-acting ten-cylinder diesel engine, 8450 s.h.p. at 115 r.p.m. Launch, August 22nd.

BOW SANTOS, cargo liner; built by Hall, Russell and Co., Ltd., for Skibsaksjeselskapet Hassel, Bergen; length between perpendiculars 395ft, breadth moulded 58ft., depth moulded to shelter deck 37ft 4in, deadweight 7700 tons on 25ft 1in summer draught; five holds, one heavy derrick, 25 tons; Wilton-Fijenoord-Doxford oil engine, five cylinders, 5500 b.h.p. at 112 r.p.m., three 150kW diesel-driven generators. Launch, August 24th.

JARENA, oil tanker; built by Harland and Wolff, Ltd., for Anders Jahre and Co., Norway; length between perpendiculars 540ft, breadth moulded 73ft, depth moulded 39ft 3in, deadweight 18,500 tons, twenty-seven cargo oil tanks, two cargo pump rooms; two 75kW steam-driven generators, one 75kW diesel-driven generator; Harland-B. and W. two-cycle, single-acting, opposed piston oil engine, six cylinders, 750mm diameter by 2000mm combined stroke, two single-ended cylindrical multitubular oil-fired boilers. Launch, August 25th.

GOLDEN BOY, bulk cement carrier; built by Henry Robb, Ltd., for the Tara Kohe Shipping Company, Ltd., Wellington, New Zealand; length overall 245ft, breadth moulded 42ft, depth moulded 18ft; mechanical loading and self-discharging equipment; two four-cylinder British Polar diesel engines, each driving through B.T.H. magnetic coupling and alternator unit. Launch, August 27th.

DJEMILA, oil tanker; built by the Chantiers Navals de La Ciotat for the Compagnie Navale des Petroles; length between perpendiculars 441ft 3in, breadth moulded 61ft 8in, depth moulded 33ft 6in, load draught 25ft 11in, deadweight 12,000 tons, speed 12 knots; Chantiers de Provence-Doxford oil engine, four cylinders, 600mm diameter by 2320mm combined stroke, 3750 b.h.p. Trial, August.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASLIB

Fri. to Mon., Sept 11th to 14th.—The University, Nottingham, 28th Annual Conference.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Sept. 30th. — LONDON SECTION: London School of Hygiene and Tropical Medicine, Keppel Street (Gower Street), W.C.1, "The Impact of Communication Theory on Television," D. A. Bell, 6.30 p.m.

ENGINEERS' GUILD

Thurs., Sept. 24th.—METROPOLITAN BRANCH: Caxton Hall, Caxton Street, Westminster, S.W.1, Annual General Meeting, 6 p.m.

INCORPORATED PLANT ENGINEERS

Tues., Oct. 6th.—EDINBURGH BRANCH: 25, Charlotte Square, Edinburgh, Members' Papers, 7 p.m.——LONDON BRANCH: Royal Society of Arts, John Adam Street, Adelphi, W.C.2, "Patterns, Casings and Foundry Work: An Introduction," Barnet Levy, 7 p.m.

Wed., Oct. 7th.—SOUTHAMPTON BRANCH: Polygon Hotel, Southampton, "Oxygen in Industry," E. Ryalls, 7 p.m.

Thurs., Oct. 8th.—N.E. BRANCH: Roadway House, Oxford Street, Newcastle upon Tyne, "The Use of Paint in Factories," P. J. Gay, 7 p.m.

INSTITUTE OF PETROLEUM

Wed., Sept. 9th.—Manson House, 26, Portland Place, London, W.1, "Autofining," F. W. B. Porter, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Wed., Sept. 16th.—N.W. CENTRE: Victoria Hotel, Wigan, "The Use and Abuse of Fuels," W. E. P. Johnson, 7.30 p.m.

Thurs., Sept. 17th.—LONDON CENTRE: Visit by party of members to the main workshops, The Thames Valley Traction Company, Ltd., Reading, Berks, 1.45 p.m.——YORKSHIRE CENTRE: Hotel Metropole, King Street, Leeds, 1, "Vehicle Maintenance from the Aspect of Safety," A. H. Dack, 7.30 p.m.

Tues., Sept. 22nd.—N.E. ENGLAND GROUP: Royal County Hotel, Durham City, "The Maintenance of High-Speed Diesel Engines," H. L. Parrish, 7 p.m.

Wed., Sept. 23rd.—LONDON CENTRE: Visit by party of members to the works of Scammell Lorries, Ltd., Watford, Herts, 10.45 a.m.

Wed., Oct. 7th.—LONDON BRANCH: Royal Society of Arts, John Adam Street, London, W.C.2, Annual General Meeting, followed by "Transport in South Africa," T. F. Turton, 6.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Sat., Oct. 10th.—Reynolds Hall, College of Technology, Manchester, George E. Davis Memorial Lecture, Norman Swindin, 3 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Sat., Sept. 12th.—N.E. STUDENTS' SECTION: Visit to Cosmos Works of the Edison Swan Electric Company, Ltd., Sunderland, 10.30 a.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., Sept. 23rd.—Institution of Mechanical Engineers, Storey's Gate, London, S.W.1, Presidential Address, R. C. Bond, 5.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Sat., Sept. 5th.—BIRMINGHAM GRADUATE SECTION: Chemistry Theatre, The University, Birmingham, National Graduates and Students Convention, 1953, 9.15 a.m.

Tues., Sept. 8th.—BIRMINGHAM GRADUATE SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, Film Evening, "Mechanical Handling," followed by a discussion, 7 p.m.

Sat., Sept. 12th.—BIRMINGHAM GRADUATE SECTION: Visit to Farnborough Air Display, 8 a.m.

IRON AND STEEL INSTITUTE

Wed., Sept. 30th, to Wed., Oct. 7th.—Special Meeting in the Netherlands.

OLD CENTRALIANS

Mon., Sept. 14th.—Chez Auguste Restaurant, 47, Frith Street, London, W.1, "Litigation with Regard to Patents," G. W. Tookey, 12.45 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues. to Fri., Sept. 8th to 18th.—LONDON: Anglo-American Conference. (See page 314.)

SOCIETY FOR WATER TREATMENT AND EXAMINATION

Thurs. to Sat., Sept. 17th to 19th.—Autumn Meeting in Manchester.